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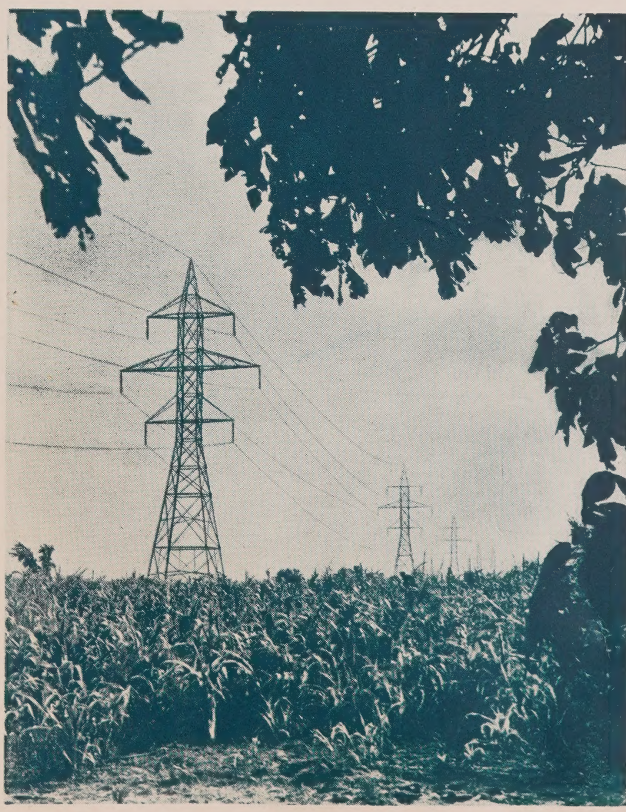
The BULLETIN

The Hydro-Electric Power Commission of Ontario

Volume XXIX | JANUARY, 1942 | Number 1



Double-circuit, 220 kv. transmission line, Toronto to Burlington.

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Municipal Loads, December, 1941

NIAGARA SYSTEM
25-Cycle

	H.P.	Population
Acton	1,610	1,903
Agincourt	212	P.V.
Ailsa Craig	147	477
Alvinston	110	663
Amherstburg	1,092	2,755
Ancaster Twp.	412	V.A.
Arkona	71	408
Aurora	1,261	2,821
Aylmer	862	1,979
Ayr	281	768
Baden	320	P.V.
Beachville	635	P.V.
Beamsville	476	1,186
Belle River	200	852
Blenheim	588	1,844
Blyth	145	656
Bolton	211	600
Bothwell	167	646
Brampton	3,047	5,695
Brantford	20,096	31,309
Brantford Twp.	1,153	V.A.
Bridgeport	167	P.V.
Brigden	89	P.V.
Brussels	170	814
Burford	218	P.V.
Burgessville	52	P.V.
Caledonia	436	1,425
Campbellville	43	P.V.
Cayuga	156	658
Chatham	7,763	16,910
Chippawa	383	1,172
Clifford	113	456
Clinton	677	1,879
Comber	147	P.V.
Cottam	99	P.V.
Courtright	56	344
Dashwood	89	P.V.
Delaware	71	P.V.
Delhi	780	2,544
Dorchester	133	P.V.
Drayton	143	528
Dresden	440	1,572
Drumbo	123	P.V.
Dublin	51	P.V.
Dundas	2,868	5,012
Dunnville	1,506	3,870
Dutton	290	843
Elmira	920	2,069
Elora	442	1,187
Embro	120	435
Erieau	86	295
Erie Beach	10	21
Essex	628	1,854
Etobicoke Twp.	7,879	V.A.
Exeter	630	1,654
Fergus	1,324	2,732

	H.P.	Population
Fonthill	206	860
Forest	534	1,520
Forest Hill	7,998	11,757
Galt	11,445	14,286
Georgetown	1,811	2,427
Glencoe	226	726
Goderich	1,553	4,484
Granton	65	P.V.
Guelph	11,419	21,518
Hagersville	952	1,369
Harriston	397	1,326
Harrow	492	1,055
Hensall	238	696
Hespeler	2,975	2,895
Highgate	106	324
Humberstone	558	2,784
Ingersoll	3,217	5,302
Jarvis	244	536
Kingsville	763	2,360
Kitchener	28,274	33,080
Lambeth	173	P.V.
LaSalle	242	873
Leamington	1,932	5,811
Listowel	1,349	2,892
London	44,092	77,369
London Twp.	673	V.A.
Long Branch	1,242	4,200
Lucan	214	599
Lynden	116	P.V.
Markham	330	1,170
Merlin	121	P.V.
Merritton	8,280	2,656
Milton	1,480	1,903
Milverton	344	997
Mimico	2,716	7,713
Mitchell	743	1,666
Moorefield	41	P.V.
Mount Brydges	114	P.V.
Newbury	34	275
New Hamburg	644	1,446
Newmarket	1,796	3,916
New Toronto	11,097	7,175
Niagara Falls	11,606	18,770
Niagara-on-the-Lake	788	1,764
Norwich	443	1,302
Oil Springs	213	515
Otterville	117	P.V.
Palmerston	629	1,393
Paris	1,967	4,604
Parkhill	232	1,022
Petrolia	1,343	2,772
Plattsville	128	P.V.
Point Edward	1,638	1,177
Port Colborne	2,299	6,483
Port Credit	923	1,906
Port Dalhousie	869	1,595
Port Dover	472	1,864

	H.P.	Population
Port Rowan	118	706
Port Stanley	331	824
Preston	3,961	6,292
Princeton	120	P.V.
Queenston	136	P.V.
Richmond Hill	498	1,317
Ridgetown	709	1,981
Riverside	1,253	5,086
Rockwood	119	P.V.
Rodney	180	763
St. Clair Beach	99	133
St. George	163	P.V.
St. Jacobs	318	P.V.
St. Marys	1,561	4,018
St. Thomas	8,495	16,362
Sarnia	11,881	18,218
Scarborough Twp.	4,920	V.A.
Seaforth	800	1,771
Simcoe	2,690	6,263
Smithville	179	P.V.
Springfield	74	395
Stamford Twp.	2,815	8,047
Stouffville	286	1,192
Stratford	7,444	17,159
Strathroy	1,350	2,806
Streetsville	242	697
Sutton	188	853
Swansea	3,708	6,375
Tavistock	628	1,080
Tecumseh	376	2,237
Thamesford	214	P.V.
Thamesville	282	826
Thedford	112	648
Thorndale	75	P.V.
Thorold	2,635	5,038
Tilbury	1,062	1,989
Tillsonburg	1,559	4,376
Toronto	381,594	649,123
Toronto Twp.	2,652	V.A.
Wallaceburg	3,235	4,783
Wardsville	44	233
Waterdown	243	892
Waterford	564	1,284
Waterloo	5,289	8,623
Watford	473	970
Welland	12,190	11,205
Wellesley	113	P.V.
West Lorne	250	783
Weston	4,672	5,784
Wheatley	210	764
Windsor	51,968	102,680
Woodbridge	631	914
Woodstock	8,799	11,418
Wyoming	91	530
York Twp.	21,028	75,842
York E. Twp.	8,593	38,054
York N. Twp.	8,656	V.A.
Zurich	123	P.V.

Hydro News

THE BULLETIN

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The Hydro-Electric Power Commission of Ontario

A Study in Public Service

Brackett Lecture Presented to the Students and Faculty of Princeton University November 18, 1941

By Dr. Thomas H. Hogg, Chairman and Chief Engineer

TO Canadians, the United States is not a foreign country: our points of view and our ways are so similar. In the engineering profession our technical practices are indistinguishable. I come to you today as an engineer; an engineer who feels very much at home and at one with you; a Canadian engineer who is happy to enjoy your hospitality and honoured to have the opportunity to speak to you.

Canada and the United States are bound together by ties of strong friendship. We are thankful for those ties. We face, today, a grim crisis: our future as democracies is in peril. Never before has the outcome rested so squarely on the shoulders of ordinary men and women everywhere. Happily, we realize that our fortunes are not in our individual keeping: as democracies we stand or fall together.

The Brackett Lectureship was established at Princeton University in the School of Engineering, in 1921, in memory of one of Princeton's most respected and beloved professors, Dr. Cyrus Fogg Brackett, Henry Professor of Physics from 1873 to 1908. The Brackett Foundation has brought to Princeton many distinguished American leaders. Dr. Hogg follows Sir Henry Thornton as the second Brackett Lecturer from Canada to address the engineering students and faculty of Princeton University.

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Vol. XXIX No. 1

JANUARY, 1942

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Last April, the President of the United States and the Prime Minister of Canada conferred as to measures by which the most prompt and effective utilization might be made of the production facilities of North America. They were concerned with both local and hemisphere defence and, in addition, with the assistance which both nations are rendering to Great Britain and other democracies.

Out of that discussion came the Hyde Park Declaration. It was agreed, that as a general principle each country should provide the other with defence articles which it is best able to produce, and produce quickly, and that the production programme should be co-ordinated to this end.*

This collaboration will have far-reaching consequences. Lessons we have learned, and are learning now, will not soon be forgotten. In later years the seeds of our mutual regard and co-operation will flourish and bear good fruit. A continuing understanding and goodwill will be forged that will bind and mould our destinies.

But our way will not always be smooth. To teach men how to live harmoniously and helpfully, to remove prejudices and abate intolerance, to point the way of sharing common benefits is not the task of a year or even of a decade. As the higher fortresses of learning, the universities represent in completest and truest form the spirit and ideals of democracy. It is for them to cherish and spread these ideals throughout the earth. They have already done much; they may, and will I am sure, do more.

For years there has been much controversy on both sides of our international boundary on the subject of public ownership. At times it has centred around the electric-supply utilities. These utilities provide a service that is indispensable; and since only one utility can operate, economically, in a given territory, consumers living in the area are obliged to buy from that utility whether its rates be high or low.

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*_The Hyde Park Declaration: Co-operation in Economic Defence_
Statement by the Rt. Hon. W. L. Mackenzie King, M.P., (April 28, 1941), pp. 6 and 7.

This situation has been a cause of anxiety. Though the operations of such utilities be conducted with efficiency and probity, suspicion of a mischievous exercise of monopoly power could not always be eradicated by assurances that all was well. Experience has shown that the untrammelled pursuit of self-interest does not always promote the common good. Self-interest often requires both restraint and direction.

Thus consumers have sought safeguards. Some have demanded that public service commissions be set up to exercise surveillance over their operations; others have demanded that these electric utilities be publicly-owned and operated.

I do not propose to debate the relative advantages of these alternatives. I do not seek to convert you to one point of view or the other. It cannot be assumed that one of these is appropriate for all circumstances. The nature of each society shapes its political and industrial development and it would be wrong to suppose that what is desirable and beneficial in one country or region is necessarily satisfactory, or even workable, in another where different traditions and conditions obtain.

In the United States reliance has been placed, to a large extent, upon public service commissions, clothed with broad powers and entrusted with the task of regulating the activities of privately-owned utilities so as to give fair treatment to owners and consumers alike. This exemplifies what has been called the typical American preference for moderation and happy compromise.

But in Ontario, Great Britain and elsewhere public ownership has been adopted more widely and has developed with advantage side by side with private ownership under governmental regulation. This development, kindled by public need, rests on public consent; it is, in no sense, an impairment of the democratic way of life.

Influences Toward Public Ownership

In tradition, Ontario is British, but in structure, technical equipment and business practice it is American. Like you, the people of Ontario possess —and have always possessed—many of the individualistic traits that are common to people of strong pioneering traditions. How, then, can one explain the development of the major part of the electric industry in Ontario under public ownership? What circumstances contributed to the creation and expansion of this enterprise, this publicly-owned enterprise which now produces and distributes electrical energy to more than eighty-five per cent of the power consumers of the Province, and ranks among the first three or four largest electric-supply utilities in the world?

Looking back, it is evident that a number of factors—strategic, political, racial and economic—combined to bring about that development. When the union of the Canadian provinces was formed in 1867 the natural resources, with certain exceptions, remained under the jurisdiction of the provincial governments. In Ontario—an area twice as large as the States of New York, Pennsylvania, Michigan, and Illinois together—those resources consisted of thousands of square miles of fertile agricultural land, vast stands

of timber, rich deposits of precious and base minerals and unexcelled water-power.

But apart from lignite deposits, commercially unusable at the time, there was no coal and little mineral oil. Coal to drive Ontario industry had to be brought from the provinces of Nova Scotia or Alberta, or from the Pennsylvania fields in the United States. This involved a long and costly haul.

To enterprising Ontario manufacturers this deficiency constituted a serious handicap, a handicap that was pressed home, painfully, in 1902, when the Pennsylvania coal strike curtailed Ontario's fuel supply, closed many factories and caused considerable hardship. The incident made a deep impression on the minds of the people and quickened interest in a drive to harness the "white coal" that nature had provided so abundantly at Niagara.

At the turn of the Century—following the general pattern of development in the United States—a few private companies secured concessions from the Government of Ontario and began installing hydro-electric equipment in the Niagara Peninsula for the generation and distribution of electric power. It became apparent soon that the Province had been endowed with one of the richest gifts of nature: a gift that does not diminish with time. Water power, unlike coal and oil, is not a wasting asset.

A coal mine becomes worked out; an oil well has a more or less definite span of life. Both enter a phase of increasing costs as they near exhaustion. Water-power, on the other hand, is not reduced or impaired by use in the long run. Subject to seasonal variations time does not diminish the flow of energy that it will yield, and yield without the necessity of any continuous expenditure of human effort comparable with that of wresting coal from the earth. In short, once a hydro-electric plant has been constructed, an unending supply of energy can be obtained with very little additional effort.

Here in Ontario, then, were unexcelled resources in water-power which, if judiciously utilized, would release labour otherwise engaged directly or indirectly in the production and transportation of coal, to improve productivity and living standards of the people. The idea of public ownership and operation gained ground and drew support from all classes. It was actively championed by municipal councils and boards of trade.

An Innovation in Statecraft

In response to this popular movement the Provincial Government appointed a special committee of enquiry and, in 1906, acting upon the committee's recommendations, passed legislation setting up a new, separate authority, The Hydro-Electric Power Commission of Ontario.

At that time there was little in the way of precedent upon which the authors of the Ontario Hydro scheme could rely for guidance. They proved, however, their wisdom and foresight by creating a type of public body or enterprise which, in the industrial field, has won increasing favour. Today, the independent commission, as a device for organizing and operating important public services, is widely acclaimed. Not only Ontario, but Canada, Great Britain, and other countries have en-

trusted the operation of many vital services to independent and semi-autonomous public commissions.

Even in the United States the independent commission, as an instrumentality of public ownership and operation, has won recognition. A conspicuous instance is the Tennessee Valley Authority. In its broad power aspects the T.V.A. was modelled after The Hydro-Electric Power Commission of Ontario, taking into account different conditions and circumstances. Many of its aims and objects are similar to those which The Hydro-Electric Power Commission has realized in Ontario.

Outline of Growth

The Hydro-Electric Power Commission of Ontario was created by special Acts of the Ontario Legislature in 1906 and 1907. At first, power was purchased from privately-owned power companies and distributed over a transmission network constructed by the Commission. Deliveries were commenced in 1910, and at the end of the year the aggregate load of the original group of ten municipalities was 3,500 horsepower. Thereafter, load growth was rapid and the Commission, hard pressed to keep pace with the demand, soon entered the field of power generation. Several plants were designed and built and, in 1917, the Ontario Power Company at Niagara Falls, the Commission's original and chief source of supply, was brought out.

Today, the Commission owns and operates forty-six hydro-electric generating plants having an installed capacity of over a million and a half horsepower. Some of these plants, were acquired by purchase. Others, totalling nearly a million horsepower, and including the 500,000 h.p. Queenston-Chippawa development at Niagara, were designed and constructed by the Commission.

In addition to the power developed by the Commission's own generating plants, about 865,000 h.p. is purchased under contract from privately-owned companies located largely in the province of Quebec, giving a total capacity of over 2,400,000 h.p. of which 2,175,000 h.p. may be termed dependable. This December the demand for primary power from the Commission will be about 2,220,000 h.p. This includes the requirements of 886 municipalities and rural districts, 152 industrial corporations, and firm export to the United States at Niagara Falls. It does not include the export of 50,000 to 100,000 horsepower to vital war industries in the United States.

The territory served by the Commission is equal in area to one and a half times the State of New York. The capital investment in plants and properties totals 363 million dollars. The capital investment of the member municipalities in local distribution systems amounts to 99 million dollars, making a total investment in the undertaking of 462 million dollars. Against this investment there are reserves and municipal surpluses aggregating 242 million dollars.

A Self-Sustained Enterprise

The Commission is composed of a Chairman and two Commissioners, appointed by the Provincial Government. One of these must be a member of the Government. The duties of the Chairman are full time, and the remuneration of the Commissioners is limited by the Power Commission Act. There

is no fixed term of office. Sir Adam Beck, who played a vital role in the creation of Ontario Hydro, and to whom much of its early success is due, served as Chairman from its inception in 1906 to his death in 1925.

Although the Comissioners are appointed by the Government, Ontario Hydro is in no way a department of the Government. It is a separate entity, a self-sustaining public concern endowed by The Power Commission Act with broad powers to develop, produce, buy and supply electricity, and to perform certain regulatory functions with respect to the activities of the public utility commissions of the member municipalities.

The Commission is subject, of course, to the ultimate control of the Provincial Legislature and in certain specific matters subject to the discretionary approval of the Cabinet; but it exercises, in practice, almost complete autonomy over its day-to-day operations.

Government participation is limited to that degree of supervision of general policies necessary for the protection of the financial guarantees that the Province has placed behind the undertaking. The Commission is free to decide the internal form of its organization and to appoint and fix the remuneration of its employees. It is fully responsible for its own solvency; and is at liberty to determine the employment of its income to meet expenses, and to provide all reserves deemed to be necessary for the protection of the Commission's undertakings.

Union of Co-operating Municipalities

Most institutions bear the impress of the forces that have led to their creation. This is very true of Hydro. Our co-operative enterprise has two distinct divisions. The first has to do with production and wholesale deliveries of power; the second with retail distribution. The generation of electric power and its transmission in wholesale quantities, at cost, to municipalities, rural power districts and other large customers is a function of the Ontario Commission. The retail distribution of electric power, at cost, in cities, towns and villages is a function of individual municipal commissions, subject to limited supervision by the Ontario Commission.

The supply of electric power to municipalities which operate their own distribution systems constitutes, from the standpoint of power load and number of consumers, by far the most important phase of the Hydro Commission's operations. Nearly 300 cities, towns, villages and suburban sections of townships receive their power supply under this arrangement. These municipalities form the basic structure of the Hydro plan just as girders form the basic structure of a building.

When a municipality enters into a contract with the Commission for the delivery of power it constructs or buys and operates its own local distribution system. It undertakes, also, as a member of the system, to repay its share of the costs incurred by the Commission in providing and transmitting power, on behalf of it and the particular group of municipalities with which it is associated.

The Power Commission Act forbids the council of a city or town to operate its local distribution system. Instead a public utility commission is established

which distributes power to consumers in the municipality at rates and under conditions approved by the Ontario Commission. These rates must be sufficient to cover the cost of wholesale power to the municipality and all other expenses of the local public utility commission, including depreciation, and retirement of the capital investment in works in a period of twenty to thirty years.

Any municipality in Ontario may become a member of the Hydro enterprise, but before a municipality can obtain a supply of power from the Commission, a vote must be taken at the polls. If the result is favourable a by-law is passed enabling the municipal authorities to enter into a contract with the Commission. The engineers of the Commission are at the service of the municipality, and upon request they will prepare and submit estimates of the cost entailed in providing the service. If the municipality is obliged to issue debentures for the purpose of financing the construction or purchase of the local distribution system a second by-law must be passed.

This service to municipalities, which is the principal concern of the Commission, was first established in Southern Ontario and in the Thunder Bay district at the head of the Great Lakes. It spread where manufacturing and agriculture had taken firm root and population was densest. Cities, towns, villages and industry were provided with power. Then lines were pushed out to serve country districts; and urban centres and rural settlements were integrated in orderly physical systems.

Rural Electric Service

The Commission's interest in rural electrification goes back to the earliest days of its administration. The social and economic advantages which accrue to rural areas through the provision of electric power have always been apparent, but the problem has been far from simple. The difficulty has been primarily one of scattered population: the small load per dollar of capital investment and mile of distribution line makes unit power costs and rates relatively high. At first, progress was slow.

The original Hydro plan for serving cities and towns, where demands are relatively concentrated, was not suited to the needs of sparsely-populated country districts. Not only were the requirements of these districts small but the Commission had to deal directly with individual consumers. It was apparent that they could not be served economically unless organized into groups of a more economical size. The first step in this direction was taken in 1920. Rural power districts were set up with boundaries determined solely by considerations of efficiency and economy. The Commission arranged for a supply of power for each district, and in each of these districts distributed power to ultimate consumers at cost.

A second step was taken in the following year when the Government passed an act, authorizing payment out of the revenues of the Province of a grant-in-aid of 50 per cent of the capital cost of rural primary lines. Since then the grant has been extended to include secondary lines, service meters and other equipment within the rural power districts.

The net effect of this subsidy is to

relieve country districts of interest and sinking fund charges on half the investment in distribution facilities. This is equivalent to about a sixth of the total yearly cost of power and operation. Besides this assistance, the Government guarantees a low maximum service charge and makes loans to farmers on favourable terms for the installation of wiring and equipment.

Under the plan introduced in 1920, each rural power district embraces an area that can be served economically from one or more points of supply; and for costing purposes, each district is an independent entity. As part of the system of co-operating municipalities, they pay the actual cost of power at the point of delivery, just as do urban municipalities. But while power distribution in cities and towns is a function of local public utility commissions, in rural power districts it is carried out directly by the Ontario Commission as trustee for the municipalities concerned.

Today, there are 132,000 rural customers served by 20,000 miles of rural primary lines which, with other rural apparatus, represent a captial investment of 39 million dollars. The Commission extends service wherever not less than two ordinary farm contracts, or their equivalent, can be made per mile of line. Had it not been for the war it is estimated that in five or six years ninety per cent of the rural population, within economic reach, would have been served with electrical energy. Unfortunately, a shortage of materials has postponed rural extensions.

Bulk Sales to Corporations

A third function of the Commission is the sale of power to certain large industrial companies. Most industrial customers are supplied by the municipalities in which they are situated. But many companies are unwilling to make long term contracts. Their supply generally requires the installation of costly equipment which is of no value to the municipalities except for providing service to these customers. In some instances the requirements of a company may be very large compared with the remaining requirements of the municipality. Thus a municipality may find it onerous, even hazardous, to supply a large company. In such cases, the company may be supplied directly by the Ontario Commission as a system customer under a fixed price contract. Rates to these companies approximate costs, but are adjusted with a view to avoiding loss. Any surplus or deficit is credited or charged, as the case may be, to the municipalities.

To summarize: the Commission supplies power to three classes of customers: municipalities, rural power districts and certain large industrial firms. These customers are now served through four co-operative systems.* Originally there were more than four systems. Each system was built around a group of municipalities which had as a common aim obtaining power from some suitable source usually out of reach of any one of them alone. In the beginning, they were often small and isolated, but as some expanded, their transmission lines approached. Tie lines united them physically, and when additional advantages became apparent, consolidation of financial and administrative functions was effected.

*The Niagara, Georgian Bay, Eastern Ontario and Thunder Bay systems. Each of the first three of these systems represents a consolidation of several smaller systems.

In Southern Ontario this integration has reached a comparatively stable condition. Three systems are physically interconnected, although their operating costs are kept separate.

NORTHERN ONTARIO PROPERTIES

Thus far we have been considering the Commission's operations in Southern Ontario and at the head of the Great Lakes. But the Commission also has generating plants and lines in Northern Ontario, a large, sparsely-settled territory which is the source not only of the world's main supply of nickel but of large quantities of copper, gold, silver, platinum and other minerals.

During the last two decades this mining industry of Ontario has grown remarkably. Since 1929, the output of copper has increased fourfold; that of nickel more than twofold. The production of gold has doubled. In 1940, minerals contributed about 14 per cent of the value of the total net production of the Province. Among the factors which stand out prominently in this striking expansion is the extension of hydro-electric service.

Power costs, as you know, form a large part of the expenses of mining operations. They exercise a telling influence on the whole industry. Every reduction in power rates tends to increase the profit of high-grade mines and to make marginal mines economically workable. Every reduction in power costs operates to postpone the day of economic exhaustion and to prolong their life.

By bringing low-cost hydro-electric power to many districts dependent formerly on steam or Diesel engines the Commission has given powerful impetus to this development. The Commission now serves more than fifty operating mines, and supplies them with hydro-electric power at progressively lower cost. In the Abitibi district, for instance, which includes the rich gold-producing Porcupine and Kirkland Lake areas, the Commission sells power at rates nearly 40 per cent lower than those current at the commencement of its operation in 1933. Notwithstanding these relatively low charges, the Northern Ontario Properties of the Commission are in a healthy financial position.

Those of you who have visited Ontario's northern playgrounds or, better still, the mining fields themselves, may form their own appraisal of the problems of supplying hydro-electric service in that region. Since the demand for electric power comes chiefly from a mining industry located deep in the wilderness, power cannot be supplied economically by extending lines from the systems of Southern Ontario. Only by developing sites close to the mining fields can this demand be met effectively. The Northern Ontario Properties of the Commission are not an outgrowth, therefore, of its Southern Ontario systems. They are an almost wholly independent development in a region where there are no large cities and, indeed, few municipalities of any size.

Partly for this reason and partly because of the hazards of mining operations, the publicly-owned properties of Northern Ontario are held by the Commission in trust for the Province and operated on the financial responsibility of the Government. The Commission administers the properties,

studies mining prospects and determines what districts can be supplied and how best to serve them. Under this arrangement the Commission's generating plants in Northern Ontario have reached an installed capacity of 310,000 h.p., involving a capital investment together with associated transmission lines and networks of 41 million dollars.

SERVICE AT COST

I have already referred to the basic principle which governs the operation of Hydro's co-operative systems: that electric service be provided by the Commission to municipalities and by municipalities to ultimate consumers at cost. As trustee for all the participating municipalities and to a large extent for final consumers, the Commission must avoid discrimination and see that no class of consumer pays more or, on the other hand, pays less than its proper proportion of the actual cost of providing service.

The municipalities make moderate surpluses from time to time; but sooner or later these surpluses are passed on to their customers in lower rates or rebates. This principle of service at cost has two advantages: first, it eliminates many claims of discrimination and injustice; and second, it tends to produce a distribution of industries and population throughout the Province favourable to production, efficiency and economy.

What does "cost" include? The Commission defines "cost" as the expenses of operation, administration and maintenance, interest on capital, taxation, purchased power, and provisions for four reserves, namely: sinking fund, depreciation, contingencies and rate stabilization, all as authorized by the Power Commission Act.

The depreciation reserve accumulates the capital sum invested in depreciable assets during the estimated life of the plant and equipment, while the sinking fund accumulates the entire capital invested in a predetermined period of years for the purpose of amortizing the capital liability. The longest sinking fund period used by the Commission is forty years.

In 1940, interest constituted 34 per cent of the total cost of power. Sinking fund provision amounted to about 8 per cent; a total of 42 per cent. This means that as the various items of capital equipment become debt free lower rates may reasonably be expected —although not of course by so large a fraction as 42 per cent; at least not for some years after all expansion ceases, for new investments, requiring payments of interest and sinking fund, overlap the old and will continue to do so for many years.

The reserve for contingencies is available to meet unforeseen expenses which may arise from time to time due to technological improvements or damage to plant and equipment or to some other incalculable cause.

The rate stabilization reserve constitutes the Commission's first line of defence in its effort to avoid variations in unit costs produced chiefly by a temporary decline in the demand for power, or by the necessity of incurring large expenditures which, in order to assure adequate bulk supplies of power for the future, provide for a time, more power than can be put to economic use.

These reserves are independent of

those established by the municipalities themselves. The municipalities, through their local public utility commissions, are required to make adequate provision for depreciation and to set aside annual sums for retirement of debt on their own distribution systems. They have made very considerable progress in this direction. At the present time two hundred municipalities have redeemed, or have sufficient cash or other liquid assets on hand to redeem, all their outstanding debentures issued for local distribution plant and equipment. This is a fact of profound significance.

Capital Funds

Since the Hydro Commission requires an unusually large investment in fixed plant and equipment in relation to its revenue the financing of its operations is of special importance. Based on its existing net debt, a decrease of 1 per cent in the rate of interest (e.g. from 4 to 3 per cent, etc.) paid by the Ontario Commission would mean a decrease in power costs of over 2 million dollars a year.

Fortunately, the Commission has always been in a position to secure money for capital expansion at relatively low rates of interest. Until the autumn of 1934, funds for financing capital works were obtained by direct requisition on the Provincial Treasury. The plan was this: about a year in advance of needs the Commission notified the Government of its requirements. A vote was taken in the Legislature and the money was raised by the sale of Provincial bonds, and made available to the Commission to be drawn upon as required under the requisition of the Chairman.

The magnitude of these Provincial advances was considerable. Of a total capital investment of 287 million dollars, in 1934, the Provincial Government had advanced 207 million dollars. Of this 17 million dollars had been repaid under an orderly plan of amortization, leaving liabilities outstanding and due the Province in 1934 of 190 million dollars.

This arrangement was advantageous at first; but as time passed it ceased to be so. The money advanced by the Government was reflected in an increase in the direct debt of the Government and this tended to give a false impression of both the size and nature of the Provincial debt. Although the portion contracted on behalf of the Commission was entirely self-sustaining, no amount of explanation could prevent misunderstanding and misuse of figures. Besides this, the calculation of interest charges payable to the Government on the money advanced became increasingly complicated owing to refunding operations and changes in interest rates. On the other hand, the Commission's practice of accumulating reserves based on adequate rates and its adherence to a general policy of sound finance added steadily to its prestige and ability to offer gilt-edge security. Thus it was able to borrow at the lowest rates of interest prevailing in the market.

In 1934, an understanding was reached with the Government that all future refunding and capital requirements involving the raising of new money would be financed by the issue of the Commission's own debentures, guaranteed, if considered advisable, by the Province. Since that year the Commission has retired 53 million dollars of its portion of the Provincial

debt and reduced the amount of its obligations to the Government to 137 million dollars. The Commission's credit is already so high that there would be no difficulty in disposing of Commission debentures at very low interest rates without the Government guarantee; and there is a possibility that in the not too distant future debentures may be so issued.

Though the Commission for many years financed a large proportion of its capital expansion by direct requisition upon the Provincial Treasury, this imposed no burden on taxpayers. The Hydro Commission has always been self-sustaining. It has reimbursed the Province annually for interest and costs incurred in raising money for the Commission. It has set aside, in addition, annual sums for the regular retirement of debt. No burden of taxation has devolved upon the people of Ontario, from Hydro's operations. True, the Government has granted a subsidy in aid of rural distribution; but this assistance is part of the Government's colonization policy designed to aid agricultural districts. The bonus is so applied that no part of it accrues to the general power systems.

The Commission's Promotional Rate Structure

It is sometimes said that non-profit-making publicly-owned utilities lack incentive, and willingness to experiment. This charge cannot be laid at the door of The Hydro-Electric Power Commission of Ontario. Let me illustrate what has happened in the field of rate-making.

In 1912, the Commission adopted a promotional rate structure and began to experiment with rate reductions. This promotional rate structure consisted of a small service charge (which, with respect to domestic service, is abolished now in most urban municipalities), a first energy charge and a much lower second or "follow-up" energy charge which applied to all power taken in excess of a specified minimum.*

To-day, the promotional rate structure is so widely accepted among rate authorities that it no longer gives rise to comment. But thirty years ago it was a bold departure from custom: its results were uncertain. Only in comparatively recent years have the advantages of this type of rate policy become so clearly apparent that it has now become quite common.

The basic idea behind the promotional rate structure is this: the greater the load density on an electric distribution system the greater the economy of operation and use of materials: the larger the demand for power the greater the opportunities of developing large power resources and the greater the economies which come from generating on a large scale. These factors lower the cost of power to consumers.

The promotional rate has played an important part in enabling the Commission to break the circle of high price and low consumption. Integrity, business efficiency and the elimination of profits are a hard combination to

*In Hamilton, a city of about 164,000 population, the first rate for domestic service is 2.16 cents net per kilowatt-hour. The second rate is .72 cents net per kilowatt-hour and this applies to all energy taken in excess of 60 kilowatt-hours per month. Since the average monthly consumption in Hamilton is 154 kilowatt-hours, a customer using that amount obtains approximately 61 per cent of his supply under the second rate of .72 cents per kilowatt-hour.

This is not exceptional. In Fort William, a city of 30,000 population, where consumption is comparatively high, the representative customer obtains 86.5 per cent of his supply under the second rate of .81 cents net per kilowatt-hour. The rate for the first 60 kilowatt-hours is 1.89 cents net per kilowatt-hour.

beat. The Commission tied power charges to costs and kept costs low. It cut rates at every opportunity, consistant with maintaining a sound financial position. The demand for electricity was found to increase rapidly as its price was reduced. The municipalities (although not the Commission) could, and did, make surpluses; but these surpluses were employed to finance capital improvements, or to reduce rates or were returned to consumers in rebates. When the cost of power was reduced and consumption increased surpluses often became even larger.

This policy has helped make it possible for domestic consumers in Ontario cities, towns and villages to reach an average monthly consumption per consumer of 175 kilowatt-hours, 2,100 kilowatt-hours per year. The average cost per kilowatt-hour for that power is only 1.25 cents and the average monthly bill is only $2.18.

The low cost of electric power to domestic consumers in Ontario has absorbed the main attention of Hydro investigators in the past. But it is noteworthy that industrial and commercial rates are also low. Moreover, industry is aided by the low cost of domestic service which helps to create and maintain attractive labour conditions in manufacturing districts.

Vigorous Policy of Expansion

When the Commission began operations the electrical industry in Ontario was immature. In some districts the Commission was first in the field and did not come into conflict with private interests. In other districts private concerns were bought out before they were firmly intrenched.

By acquiring plants and properties before they had expanded into large scale systems, and by standardizing and interconnecting these properties in the incipient stages of their development, the Commission avoided, to a considerable extent, the payment of large sums for plant and equipment which would not have lent itself advantageously to consolidation. Expenditures for changing over non-standard frequency, distribution voltages and inadequate switch gear, would have been much greater had these consolidations under the Commission been deferred. Fortunately, The Hydro-Electric Power Commission was early in the field. Had it not been, these economies would have been much more difficult, if not impossible, to attain.

Centralization and Decentralization

Besides these economies the Hydro Commission enjoys many of the advantages which come from combining centralization with local independence and freedom of action.

In the hands of the central management are concentrated all the duties and functions associated with the orderly production or purchase of bulk supplies of power and its transmission to the member municipalities and other customers. In its hands, too, rests the responsibility of formulating and executing long-term policies for the development of new sources of electrical energy and of giving general guidance to the whole undertaking.

The Commission is empowered to enforce certain general rules that ensure uniform standards or prevent anomalies in the exercise of local powers which might endanger the fortunes of other municipalities. For example:

the Commission prescribes uniform methods of keeping accounts (a fact which has enabled the maintenance of uniform statistical records dating back to the earliest years of the Commission's operations); it approves and controls rates and municipal surpluses; its assent is required for the passage of by-laws to finance local hydro-electric extensions or improvements.

But with the exercise of these safeguards and the delivery of bulk power at wholesale rates, the Ontario Commission's responsibility ends. Each municipal public utility commission is free to operate its own distribution system and to initiate and pursue policies which it deems to be suited to its particular needs.

Yet this precise division of responsibility is not a barrier to mutual assistance. A close relationship exists between the Ontario Commission and the municipalities. There is a continuous exchange of ideas, constructive suggestions, and requests from the municipalities for technical assistance. The Commission exercises general supervision over the whole municipal electrical undertaking, but that measure of local independence and flexibility necessary for initiative, vigour and efficiency is preserved.

No small part of Hydro's success in meeting the requirements of the present war emergency is due to these characteristics which have enabled the Ontario Commission to deal with problems in a comprehensive way, while leaving the local commissions to work out the detailed application of general policies to suit their individual needs.

A League of Municipalities

The Hydro-Electric Power Commission of Ontario originated as a municipal movement championed by boards of trade and manufacturers. Its supporters were city councillors, legislative members, business men, and consumers of electric power. In general, they had no ambitious political aims. Their prime concern was to obtain reliable low-cost power, nothing more.

But they believed this could not be accomplished in full measure if the production and transmission of electric power became concentrated in the hands of privately-owned companies. They were convinced that it could not be achieved by municipally-owned plants operating independently and in isolation. Niagara Falls was a source of power too large and too distant for a single municipality to exploit. They believed, however, that what could not be done separately might be accomplished by "a league of municipalities" with common interests entrusted to a publicly-owned central supply organization.

They knew that in unity there is strength; but they were aware, too, of the problems that confront a group of municipalities in uniting in a large co-operative undertaking: the suspicion as to one another's aims, the parochial viewpoint of many municipalities, the difficulties encountered by statesmen and councillors in securing re-election unless able to convince voters that their first concern is for their own community and its special interests. No one knew better than they that the road of municipal co-operation in a joint undertaking is perilous and difficult.

But in Ontario the need was great and these obstacles were surmounted. Skepticism and suspicion gave way to confidence. The small, original group

of less than a dozen municipalities grew, with the addition of rural power districts, to 886. Municipalities joined the partnership voluntarily and with the full assent and approval of the majority of the voters. It was not merely a matter of entering into a contract with the Commission for the delivery of power at a specified price for a certain number of years. In becoming a member each municipality shouldered its share of the responsibilities of the enterprise and pledged its credit to repay in annual instalments all the expenses incurred from time to time by the Commission on its behalf. For the inhabitants of these municipalities to have authorized their elected representatives to enter such an arrangement stands as a tribute to the integrity, wise judgment and good management of the Hydro Commission.

Qualities that Invite Consideration

We have sought to build into this Hydro organization a deep sense of public responsibility. We have adhered to the merit system in the appointment and promotion of personnel. Employees have been offered fair wages and a high degree of security of employment. Intelligent application, industry and loyalty have been demanded in return. In the quest for low costs and dependability these have stood us in good stead.

The super-power concept was early put into practice. We were using 110,000-volt lines in 1910 and 220,000-volt lines in 1928. The Commission was among the first to apply to whole transmission networks highspeed protective methods. It drew on the fund of knowledge common to all electric-supply utilities, but it had its own way, too, of accomplishing things.

Reductions in power costs have brought advantages: the lower the cost the greater the consumption: the greater the consumption the larger the economic and social benefits. The paths which the Commission trod were not always marked clearly, but they were grounded in sound principles and sober considerations. To liberate industry from complete dependence on coal, to make industry thrive and wealth increase, to raise the standard of comfort of the people—these have been the ultimate aims of the Commission.

Over the portals of the Commission's main administration building is the inscription: "The Gifts of Nature are for the People". With respect to water power, Ontario Hydro has made that a living reality. With foresight and vigour the Commission has harnessed the native power resources of the Province to render to the people an efficient low-cost electric service. These are achievements of which the Commission is justly proud. These are qualities which merit thoughtful consideration.

Design for Minimized Transmission Wire Contacts

By A. E. Davison, Transmission Engineer, H.E.P.C. of Ontario

ENGINEERS are always studying ways and means by which service securities within new and modernized transmission, distribution and communication systems using aerial conductors can be economically secured. In this study, comparisons of available operating records and of clearance charts of existing transmission lines may be used to forecast the performance of new designs when operating under stress. The purpose of this article is to review the characteristics of lines having certain conductor clearances which have operated reasonably well (except during glaze storms) over a long period of time, and then point out economically desirable increments in wire spacings which will reduce still further the frequency of outages. The accompanying drawings, which are to scale, show the application of "loops" or ellipses to several types of old and new transmission structures, and may assist those who attempt to apply these loops or figures to those lines which require study because of their operating characteristics. Procedures in making analyses are outlined, with examples. References are made to articles already available which describe how practical loops were developed and how they are applied to practical cases. Glaze rejections are discussed.

The Problem and Procedure

Now that lightning-proof designs seem within the realm of possibility, the most important single consideration in any effort to ensure continuous service over modern, mechanically secure transmission lines is clearance of electrical conductors from one another and from electrically grounded objects at all times and during all kinds of weather. It would appear that engineers have not until recently seriously examined the clearance requirements of conductors. These comparisons have now been made (1) and operating experience of lines having many like characteristics, but in which clearances differ, has been recorded. These recorded data show conclusively that greater service security results from greater conductor clearance.

When engineers are concerned about glaze formations and wish to study lines whose operating record during glaze storms is not satisfactory, then some norm or procedure for comparison is necessary. One procedure which has been used is described in a technical report (2). In that report, several typical cases of galloping are chosen from a number of authentic records, and from these field data a desirable or practical (the report says, "In the absence of a better clearance diagram . . . use this") clearance chart which can be applied to all lines is developed and recorded.

Since that technical report was issued, a further study has been made of the so-called "practical" loop, its dimensions and its relation to the stabilized sag at 30 mile wind and ½ in. ice. Moving pictures of some eleven cases

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of galloping were each examined by four engineers. An effort was made to discover the highest and the lowest points of gallop with respect to the point of support, and where and what the maximum horizontal motions were. These observations were corrected in some cases by a further review of the films. The average, rather than the maximum, of the amounts reported by the four observers for the total vertical motion was recorded in each case, also the average horizontal motion and the average distance which the galloping conductor travels above the point of support and below the stabilized sag point. All dimensions were expressed in per cent of the loaded conductor sag. The eleven sets of average loop boundaries so obtained were then averaged and combined with the average of the seven authenticated cases described in the technical report, and averaged again.

It was found that the dimensions for this new average figure were greater than for the "practical" figures, but only by approximately 5 per cent. These efforts to establish an average case disclosed the fact that the whole figure is moved upwards with reference to the point of support by approximately 15 per cent of the sag when compared with the location of the "practical" loop. This fact does not change the relation of one loop to another, since all loops are moved upwards, and for that reason no change is now suggested in the so-called "practical" loops as a result of this study. It is understood, as stated in the technical report and as all who have had experience with galloping know, that these proposed clearances are not a guarantee; they simply give the designer, who is not familiar with galloping, that area which his cable occupies in most but not all glaze storms with following winds. With only one or two exceptions, the galloping studied had one or more node points per span.

Other norms could of course be set up; however, that would necessitate re-charting of all existing records. Some of the developments and trends in clearances and phase configurations within one large electrical system during a number of years are herein recorded and discussed. Other trends may be recognized from a study of the diagrams.

Once a design has been executed in the field, the difficulties in securing more desirable clearances force drastic changes such as from double- to single-circuit. There are also many limitations, the principal one being an already established minimum clearance to ground.

Designers' Problems

Some designers of transmission lines elect to use the presumed economies which are largely first cost and which result from the use of higher mechanical tensions and longer spans, even if it should later be established that security of service, for instance, had been depreciated somewhat. Others take the stand that lesser sags and mechanical tensions mean less need for greater clearances between phases and fewer hazards. They think the result will be longer life and greater securities, but, in most cases, somewhat greater first cost.

There is, in the following examples and comparative studies, some evidence that the development of clearances and

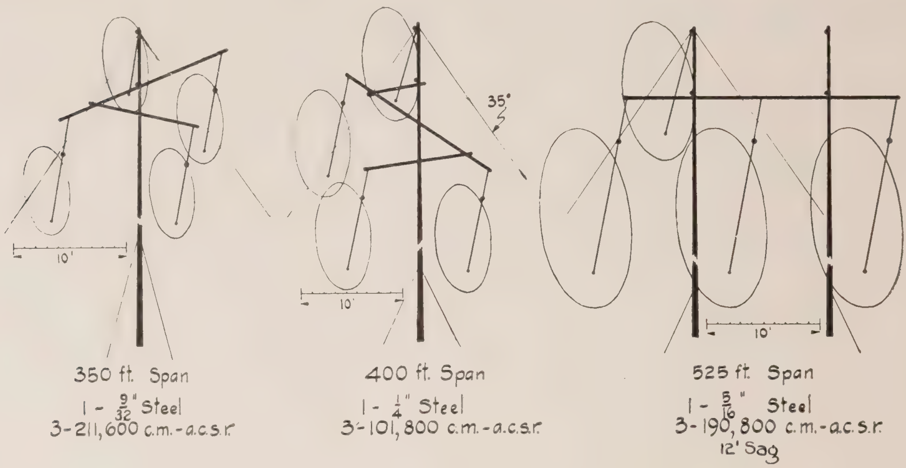


Fig. 1.—Advantages of short spans with relatively smaller whipping areas are evident. The dots indicate each end of that sag which was used in determining the controlling dimensions for the loop (Lissajous figure). Thirty-five degree shielding lines for lightning protection are drawn from each "sky-cable" support; some authorities recommend thirty degrees. The sag on the right is 12 feet using 50-foot poles; this configuration has been used on 60-foot poles, 16-foot sag, span 525 feet; loops are then relatively the same as in single-circuit, 220-kv. of Fig. 4.

satisfactory configurations in double-circuit lines has not been either as rapid or as effective as in single-circuit construction. This may be due to the fact that double-circuit lines are built with economies more in mind than securities, since they are less expensive per circuit mile or per kilowatt transmitted. So far as security is concerned, however, trouble in one circuit is sometimes carried over to the neighbouring circuit on the same structure. Records indicate that every third or every fourth outage in one circuit occurs either simultaneously in both circuits or the fault is communicated to the second circuit.

Wood-Supported Lines

The two types of wood-supported, higher voltage lines shown in Fig. 1 indicate on a comparative basis the effectiveness of short spans in providing areas within which a point on the conductor near the centre of the span may whip about in space and still have sufficient electrical clearance to keep flashovers at a minimum. If the poles do not extend above the arm attachment so that the sky cable can be attached five feet or so above the uppermost arm attachment, then clearances between sky cable and phases will be deficient. In this and the following charts, a filled circle or dot is indicated at each end of that sag used for each cable in determining the controlling dimensions for each loop.

The sloping straight lines which are in this case at an angle of 35 degrees from the sky-cable support, mark boundaries of the area within which shielding from lightning may be ex-

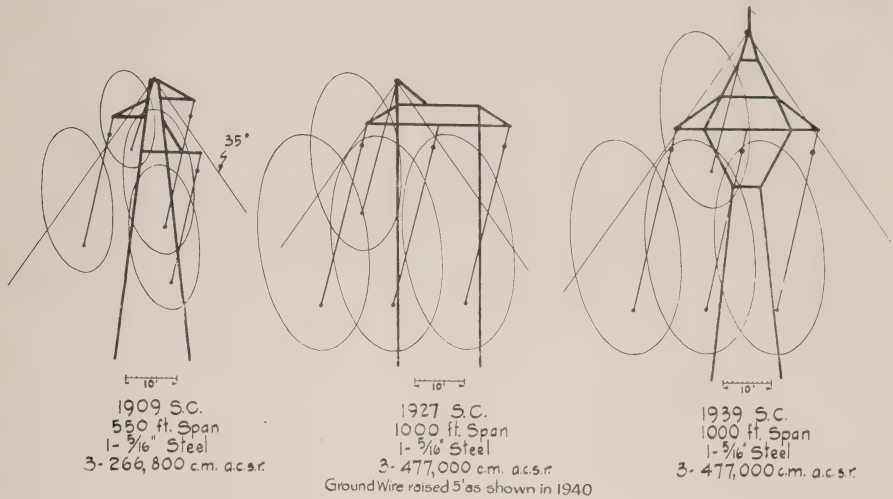


Fig. 2.—All three configurations indicate, because of the amount of sag which can be estimated from the scale chart, that conductors will, if they move about, contact one another as they do in practice during certain sleet storms.

pected for each phase wire. Wagner suggests 30 degrees as optimum (3). For the single-pole supports in Fig. 1, one phase is not as well shielded as all phases appear to be on the two-pole structures; however, experience with shielding indicates that if all phases are within a 45-degree shielding area, then extra expense in raising the sky cable is not usually warranted.

If communication circuits or other auxiliary wires must be added to either of these wood-supported higher voltage services, then clearances of necessity become very much more restricted, since poles long enough to provide safe vertical clearances are not economically available.

Single-Circuit Steel Supports —110 kv.

Types of single-circuit steel supports are compared in Fig. 2. In some of the later types, it is evident that an effort has been made to get the sky cable out of the area within which the phases are indicated as moving about. In the 1939 type, the point of support of the sky cable has been moved very much higher than usual above the middle phase position.

The sag in some of the more recent designs for steel supports, being one and a half to two times as great as that found in almost any wood construction, creates some difficulty; however, it is hoped by some engineers that the inherently heavier cables will not move around when glaze-coated as much as is indicated by the chart.

Double-Circuit Construction Steel Supports, 110 kv.

The double-circuit construction shown in Fig. 3 is not relatively desirable when comparing loops within which the phases at mid-span may travel.

220-kv. Steel Supports

Relatively good performance is

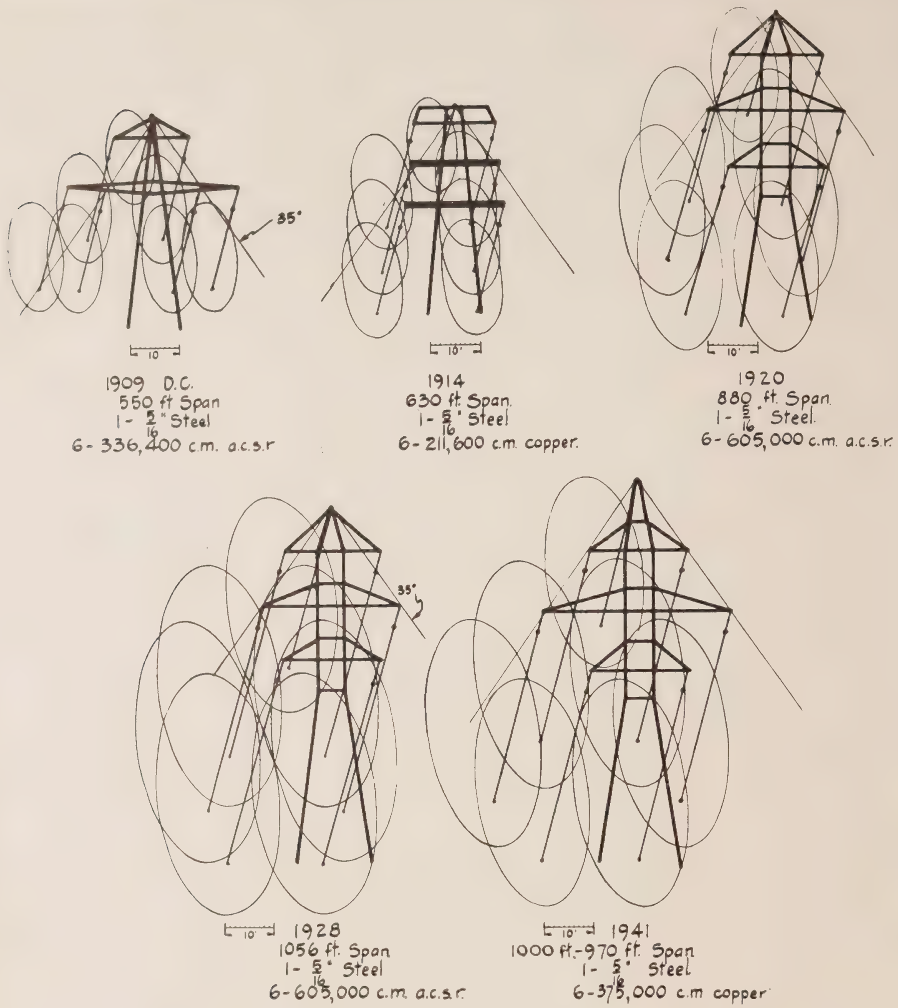


Fig. 3.—What may happen if too many wires are supported by one single-shaft structure. The charts are on a basis by which they can be fairly compared with other charts. Some orthodox configurations of the 1920's are typified. Large conductors may perform during glaze storms with following winds a little differently from smaller conductors with shorter spans. The chart to left and that to left of Fig. 2 may have identical sags in practice.

looked for from the double-circuit tower shown in Fig. 4. The loops are on the same basis as those for the 110-kv. double-circuit towers of Fig. 3. In some earlier records of this configuration, loops were placed around the sag less the eight-foot insulator, giving somewhat better clearances than actually exist.

For the single-circuit 220-kv. lines,

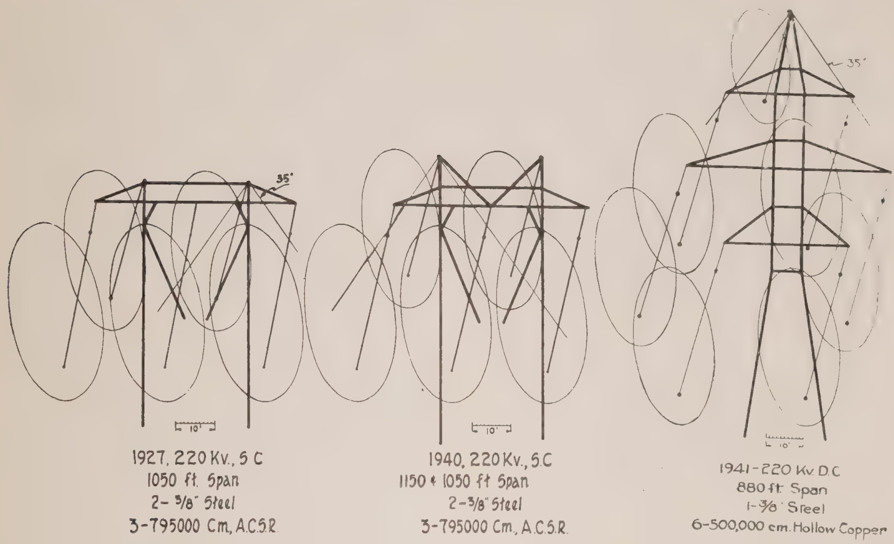


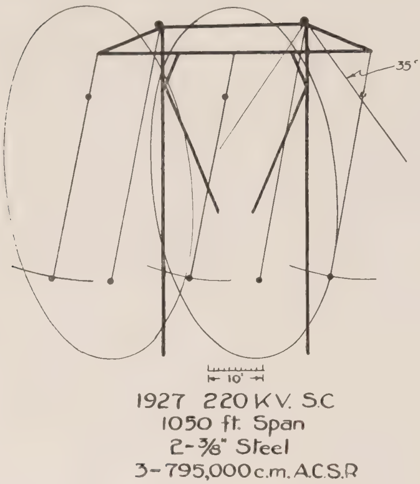
Fig. 4.—The lightning protection or umbrella effect of some of the more modern configurations are relatively good. There is evidence of progressive improvement in clearances. The corrected sags, about which loops for six conductors in the chart to the right are made, are noticeably larger than those previously submitted to the technical press.

the sky cable has been moved upwards eight feet out of the area occupied by the phases, as it has been found from experience with lightning and glaze, 1927 to 1941, that such a change is desirable. These changes are minor, since the older circuits have been operating at an outage rate of 1.15 per 100 miles per year, practically all due to lightning, and because the revised height of sky cable is the maximum that can be used safely on already available structures.

Preventing of Glaze Formation

Sky cables, normally some 13 feet above the power cables, have been found at some glaze-forming temperatures so loaded that their sag has been increased by 13 or more feet, while the conductors underneath continued to operate with little or no glaze load. Fig. 5 illustrates what would happen if there were, under such a condition, a following wind which would move the loaded sky cable about, and at the same time cause the glaze-free conductors to swing in an arc due to gusty winds.

Clem (4) has established from the then available data and experiments that glaze can be melted off conductors. Using his methods, Fig. 6 is submitted; however, all the points on the chart have been plotted from information gained from actual field cases in which formation of glaze was either prevented or greatly retarded, but not necessarily actually melted off the cables. Most of the cases occurred when air temperatures were not far removed from 32 deg. fahr., and when the air was relatively quiet. The currents recorded



At left:—

Fig. 5.—Observers in the field record that glaze-loaded sky cables had stretched so that the lowest points of sag were at the same elevation as the conductors unloaded due to internal heat. These conductors are sagged normally to a point 13 ft. 6 in. below the sky cables.

are therefore minimum. The lower boundary of the hatched area on this chart connects up these minimum electrical currents. It is not intended that this hatched area covers glaze melting at low air temperatures or that glaze rejection at the recorded electrical loads can be depended upon. Rejection of glaze, however, did occur. A dotted line curve is added to this chart. It is taken from Luke's (5) curves for 10 deg. cent. rise in still air on account of electrical heating.

RECOMMENDATIONS AND CONCLUSIONS

1. It is recommended that engineers supervising the operation of transmission systems, having provided as great wire separations as are economically possible, should establish special oper-

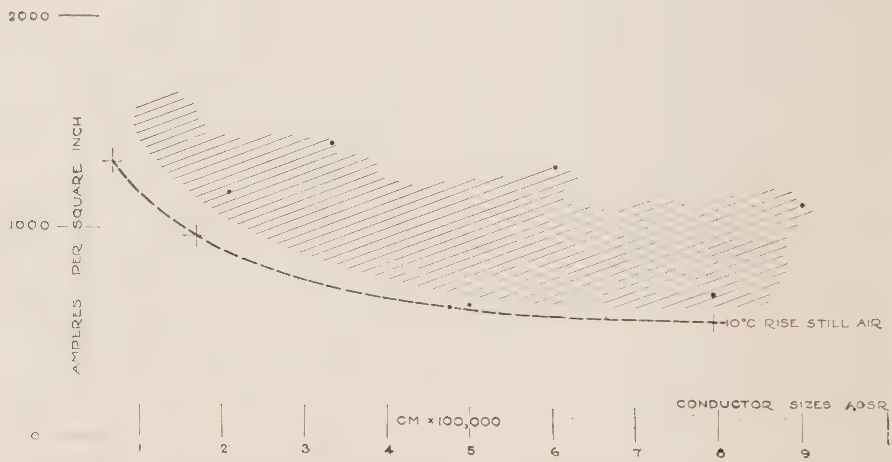


Fig. 6.—Amperages by which phases were kept clear of glaze while ice was forming on ground wires and on other cold conductors. The four cases having the lowest amperage are quite likely minimum. The lower margin of the hatched area indicates a line along which glaze rejection may be expected for many sleet storms. The parallel dotted line is a record of a 10-degree centigrade rise of temperature in still air for aluminum conductors (Luke).

ating procedures by which many glaze formations can, as in the above field cases, be prevented or retarded to a minimum. This can be done by routing available loads over lines in the glaze-forming area and by imposing, if necessary, artificial loads at normal voltages on the conductors.

Operators may not always know when, how, and where glaze is forming; however, weather bureaus, now air-transport-conscious, are beginning to attach greater importance to the forecasting of fog and glaze storms. Weather reports during critical glaze periods should be watched by operators more closely in future. Fogs which warrant keeping airplanes grounded are now being predicted (6) at Miami. Researches may provide facilities for predicting glaze.

As an alternative to overloading lines at normal voltages, special arrangements, using high current flow, have been and can be set up; however, there is evidence that glaze can form faster on one of two parallel circuits, for instance, than it can be safely melted off the remaining circuit.

2. More complete data—including operating procedure, electrical set-up, air temperature, wind velocity and direction, and successful glaze forecasting, for known cases of glaze rejection—are sought.

3. Transmission structures should be kept as clear as possible of auxiliary services or facilities. This recommendation is inclusive and applies to any wire or transposition that is known not to be essential.

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Arc Welding in War Production

THE magnificent resistance of our Russian Allies against the Nazi thrusts during the first six months, and their assumption of the initiative early in December cannot fail to excite and win the admiration of all of the free nations of the world. This, however, is not Russia's only contribution to the Allied Cause. The art of Arc Welding, one of the most powerful weapons used in the manufacture and assembly of war material known in the world today, was invented in Russia.

About fifty years ago, Bernadoz and Demeritus invented the Carbon Arc; to be followed in about five years by the Metallic Arc, which was invented by Slavianoff. All of these inventors were Russians, and while their discoveries lay comparatively dormant for three decades, necessity, which in this case was not only the mother of invention but also of application, brought these discoveries to the front in 1917 on the entry of the United States into the first World War. Several German ships lying in U.S. ports were damaged by their crews and a Committee of Scientists and Engineers appointed by the U.S. Government decided that arc welding was the quickest and most suitable method of repairing these ships. The result was that in a comparatively short time, they were made sea worthy and thus was laid the foundation of one of the most efficient processes used today for the manufacture of arms and other war needs.

The Germans were not slow in recognizing the merits of arc welding and their three pocket battleships, including the Graf Spee, were all welded.

Let us examine in detail a few of the branches of war effort in which arc welding is used:

1. In the structural field where buildings to house war projects are being fabricated.

2. In the building of merchant and battleships some of which are of wholly welded design and others partly so.

3. In the manufacture of armoured vehicles such as tanks and similar structures.

4. In various applications in the fabrication of the auxiliary parts of guns and other heavy ordnance.

5. In the fabrication of power plants for making munitions.

6. In making the component parts of light and heavy machine tools used in the various operations in manufacturing plants.

7. In effecting repairs to warships and merchant ships.

In all of these spheres, arc welding has these advantages:

1. A standard of efficiency at least as good and in many cases better than the old accepted methods.

2. Speed superior to the old-fashioned methods of fabrication previously employed.

3. A considerable saving in the weight of steel or other material, amounting to as much as fourteen per cent in some cases.

It is hardly necessary to emphasize the importance of these advantages at the present time. Speed of execution, efficiency in workmanship, and saving of materials are among the vital necessities for Victory.

To the Engineer and the Designer, whether engaged in civil or on military

activities, this is an appeal to use arc welded designs where possible and compatible with the general scheme of things.

To the shop superintendent or foreman, it is a plea to encourage their welders to maintain a high standard of workmanship consistent with rapid production.

And to all welders and workmen, it is a request to do their utmost in turning out equipment of the very highest quality.

There are about 100,000 welders in the United States and Canada, and their co-operation in the use of arc welding in the production of war equipment will be an important factor in securing ultimate Victory.—*W.D.W.*

Laboratories Extend Meter Testing Service

By G. B. Tebo, Testing Engineer, H.E.P.C. of Ontario

FOR more than twenty-five years, the Laboratories of the Commission have included the reconditioning of watt-hour meters among their many services. This service has been particularly helpful to many smaller municipalities and districts where the cost of maintaining a properly staffed and equipped meter shop would have been excessive. During the past few years, increased difficulty in obtaining satisfactory repair work which would meet the more rigid requirements of the Department of Trade and Commerce, led to a substantial increase in the number of meters sent to the laboratory for reconditioning.

In order to minimize shipping charges, and to reduce the outage from service required for reverification of meters, test panels have been permanently installed in some districts and operated under laboratory supervision. The requirements of other districts seemed to justify the assembly of portable meter-testing panels which could be transported from the laboratory to chosen locations at which meters from the surrounding district had been accumulated. The design of portable test equipment for this service presented some interesting problems. The requirements to be met were briefly:

(1) Meter test panels supplied from a single phase 30 ampere circuit should provide facilities for testing single phase or polyphase watt-hour or demand meters up to 100 amperes capacity and up to 575 volts, unity or 50 per cent power factor. It should also provide convenience outlets and adequate lighting for both repair and test work.

(2) The test panels should be of a size, weight and type of construction which would permit them to be transported in a light truck, together with a stock of tools and meter repair parts.

One of the two five-meter test panels designed and built at the laboratories to meet these requirements is shown in Fig. 1. The frame is of welded construction, mounted on ball bearing swivel casters. A low centre of gravity is obtained by mounting the heavier components immediately above the casters. Although one complete panel weighs about 400 pounds, it may be

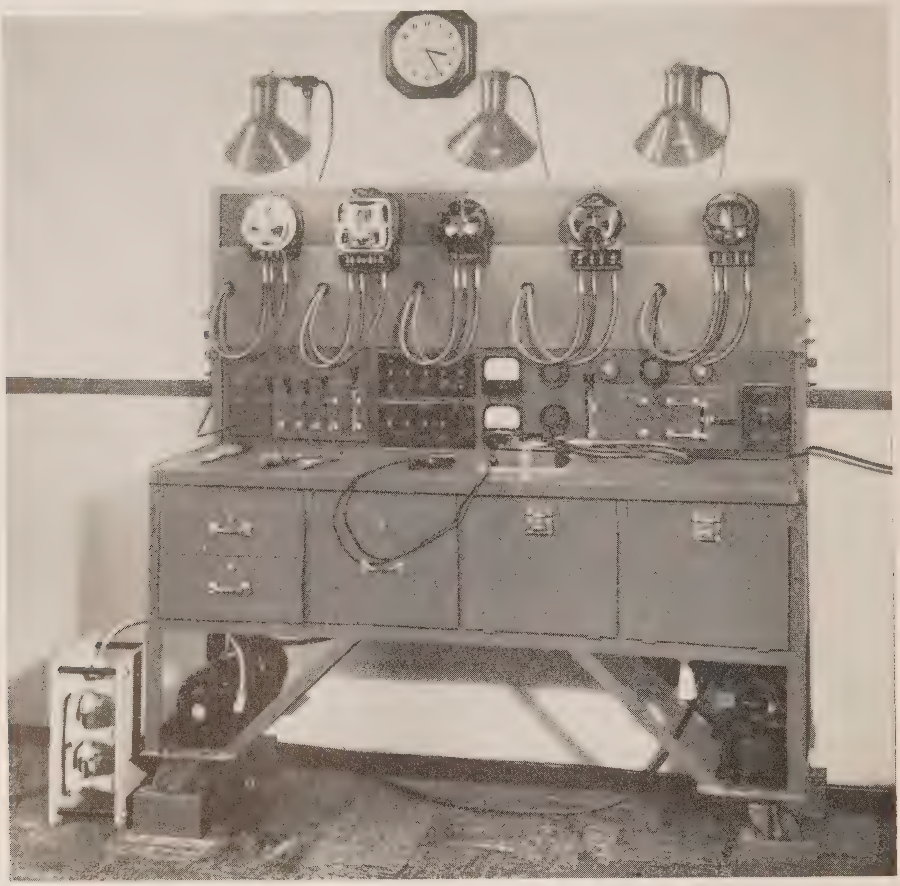

Fig. 1.—Five-meter, portable test panel.

loaded on the truck by two men, using a channel iron ramp as shown in Fig. 2. The truck accommodates two complete panels, which are set up on mounting blocks to take the weight off the casters, and bolted to the floor boards for shipment.

The control panel and table top are of plywood, reinforced on all edges by the angle iron frame, and protected on working surfaces by linoleum. The panel is "dead front" with the exception of switches in the current circuit which are maintained near ground potential. Ample cupboard and drawer space is provided for packing of tools, spare parts, load bank, lights, etc. The load bank is unique in that it is built as a unit, of heat-resistant materials, and by extending a flexible cable may be placed at some distance from the board when in operation.

The hinging of the vertical panel which permits transportation within the limited headroom available in a half-ton truck is illustrated in Fig. 2. This feature required careful design of the control panel, on which it was desired to have adequate facilities, and

Fig. 2.—Test panel being loaded into truck.

yet for which an area of only 10 inches by 5 feet was available.

The circuit provides direct resistance loading up to 15 amperes, and for higher loads, a switch transfers this resistance load to the primary of a 10 to 1 step-up current transformer. Loads are selected on a 5-gang flush toggle switch assembly, with fine control on a rheostat. Potentials of 115, 230 or 575 volts are available from a selector switch, and adjustment of voltage is available in twelve 1½ per cent steps by means of a rotary switch. As a warning against accidental selection of too high a voltage, a neon lamp is installed in a conspicuous location. The lamp is dark when 115 volts is applied to the meters, lights at 230 volts and glows brightly at 575 volts.

Fifty per cent power factor is obtained by means of a single phase, ¼ h.p. motor, of which the starting winding when in the running position, generates 115 volts which leads the supply voltage by 60 degrees. Two of these phase shift motors are provided, one for 25 cycle and one for 60 cycle. Selection of 50 per cent or unity power factor is made by means of a flush toggle switch on the panel.

For testing meter insulation, a test probe is provided which is connected to the 575 volt transformer terminal, through a suitable resistor and a neon lamp. The meters are hung on a grounded frame, so that when the probe contacts the meter terminals, lighting of the lamp indicates an insulation failure. As a safety measure, provision is made for grounding the metal frame at the test location. Also, when connecting to the 115 volt supply, a test switch is provided to ensure that the grounded side of the supply is the one which connects to the current circuit.

Six months' operation of this new meter testing service has shown that the equipment functions well, stands up under the severe conditions of transportation by truck, and that the system of field testing forms a valuable addition to the Commission's testing facilities. Of particular value at the present time is the reduction of service interruption required in reconditioning watt-hour meters for which replacement stocks are dwindling.

Hydro-Electric Progress in Canada During 1941

THE annual review of hydro-electric progress in Canada prepared by the Dominion Water and Power Bureau, Department of Mines and Resources, Ottawa, indicates the continued intensive efforts of the hydro-electric industry to meet the constantly growing demands for power for war purposes. These demands were met by the bringing into production of new water-power installations, by the construction of new transmission line facilities and the interconnection of existing transmission systems, by the diversion to primary use of large amounts of hydro-electric energy that had formerly been sold as secondary power for steam raising in electric boilers, and by the continuation of daylight saving during the winter months.

The increasing demand for power is shown by the monthly figures of output of Canada's central electric stations as compiled by the Dominion Bureau of Statistics. For the ten months ended with October the total output was more than eight per cent in excess of the output for the corresponding period in 1940 and there is every indication that the total output for the year will reach a new record of more than 33 billions of kilowatt hours. Of greater significance is the increase of twenty-two per cent during the first ten months of the year in the power generated for primary use in Canada. This indicates the great increase in industrial activity due to war production and reflects the very substantial diversion of secondary energy to primary use to which reference has already been made. Compared with 1939 this diversion of secondary energy to primary use is equivalent to about 640,000 continuous horse-power.

New water-power installations during 1941 totalled 254,600 h.p. This, together with 6,000 h.p. resulting from equipment replacement not previously reported brings Canada's total hydraulic installation as of January 1, 1942 to 8,845,038 h.p. There are, as well, other undertakings under way which should add more than 650,000 horse-power to this total during the next year and a half. Transmission line extensions and interconnections of existing systems carried out during the year were of the utmost importance in facilitating the effective exchange of hydro-electric energy in certain areas, thereby utilizing available power supplies to the greatest advantage for increased war production.

British Columbia

Although no new hydraulic turbine installations were made in British Columbia during 1941 the greatly increased power demand of the munitions industries necessitated a number of extensions and interconnections of the existing transmission systems and the construction of new substations in the lower mainland area. Similar conditions on Vancouver island have necessitated the installation of additional fuel-power equipment in the Brentwood Bay generating station.

Northwest Territories

The construction of the first hydro-electric generating station in the North-

west Territories was completed by the Consolidated Mining and Smelting Company. This plant, on Yellowknife river at the outlet of Bluefish lake provides power for the gold mines of the company and other operators and for the settlement of Yellowknife.

Ontario

Because of the greatly increased industrial load at Sault Ste. Marie the Great Lakes Power Company doubled the capacity of its plant at Upper Falls on Montreal river by the addition of a 10,000-h.p. unit.

The Hydro-Electric Power Commission of Ontario is now delivering power from its new station at Big Eddy on Musquash river. The installation consists of two units of 4,950 h.p. each and the plant will be operated by remote control from the Ragged Rapids station four miles upstream to provide additional power for the Georgian Bay system.

As a result of special agreements between Canada and the United States, additional diversions of water for power purposes have been made at Niagara Falls. These successive additions total 14,000 cubic feet per second, thereby permitting the full-time operation of all generating stations on the Canadian side of the falls.

Quebec

New hydraulic installation in Quebec during 1941 totalled 230,000 h.p. This was largely made up of additions and betterments to existing plants, the only new plant brought into operation being that of the Quebec Streams Commission on the upper Ottawa river where 48,000 h.p. has been installed to augment the power supply of the northwestern Quebec mining areas.

The Aluminum Power Company added 15,000 h.p. to the capacity of its Chute-a-Caron generating station by replacing the runners on three of its turbines thereby increasing each from 65,000 to 70,000 h.p.

The Shawinigan Water and Power Company, by the replacement of a turbine runner, increased the capacity of its La Gabelle station by 6,000 h.p. to 172,000 h.p. Two thousand horsepower was added to the Grand' Mere station by a similar replacement and its capacity is now 197,000 h.p., inclusive of runner replacements of 6,000 h.p. not previously reported.

Nova Scotia

The Avon River Power Company, a subsidiary of the Nova Scotia Light and Power Company, replaced the temporary generator of 3,500 kv-a. in its Hollow Bridge Station on Black river with one of 6,250 kv-a.

Obituary

E. W. McCulloch, Brampton

Ernest Weir McCulloch, chairman of the Hydro-Electric Commission of Brampton, passed away on Thursday, January 22nd, 1942, in his 55th year.

Mr. McCulloch was a native of Brampton and was associated with the McCulloch Planing Mills of which he became manager on his father's retirement. He entered the service of the town when elected to the council in 1929. In 1930 he was deputy reeve and reeve from 1932 to 1934; being warden of the county of Peel in 1933. For 1935 and 1936 he was mayor of the town of Brampton. On the retirement of the late T. W. Duggan in 1938, he was elected to the local Hydro-Electric Commission, and appointed chairman, to which office he was returned each succeeding year. At the first meeting of the Brampton Commission for 1942, he became chairman for his fifth term. He was keenly interested in the work of the Ontario Municipal Electric Association and of District No. 4 of that organization.

An active promoter of plans for the improvement of Brampton, he was largely responsible for the cleaning up and re-lighting the main street, which is but one example.

A. L. Sloat, Humberstone

The village of Humberstone suffered a severe loss in the sudden death, on the evening of Monday, January 19, 1942, of Alfred LeRoy Sloat, superintendent of the Humberstone Hydro-Electric System, in his fifty-first year.

"Roy" was a life-long resident of Port Colborne and Humberstone and his death came as a shock to those communities and the surrounding district where he was widely known and respected. Prior to 1926, when he entered the employ of the Humberstone commission, he had been with the Canada Cement Company and the Port Colborne Hydro-Electric Commission. In 1929 he was also appointed to the Humberstone police force and in 1930 was made chief constable. He also served as weed inspector and sanitary inspector of the village.

Almost every organization in Humberstone has benefited at one time or another by Mr. Sloat's activities, as he was ever ready to lend a willing hand in the performance of his many duties.

The Polarity of Lightning

ELECTRICAL discharges in the atmosphere, of which lightning is the most spectacular form, are probably of more interest to engineers engaged in the maintenance and operation of transmission lines than to anyone else. The destructive effect of lightning is, however, the concern of everyone and the aggregate sum spent in attempts to eliminate, or minimise, damage to buildings must be very large. It has been estimated that at any given moment there are about ten thousand thunderstorms in operation in the world. These are so widely spread that consideration of their effects is not confined to any country, or any continent. As is generally known, thunderstorms are frequent and violent in the tropics, but actually in those regions discharges between clouds predominate and discharges to earth are relatively more common in temperate countries. A lightning conductor as ordinarily installed is no guarantee of complete protection. It should be bonded to all metal work and, indeed, to do the job properly, the whole building should be enclosed in a Faraday cage.

The Kelvin Lecture of 1929, by Sir George Simpson was concerned with the subject of lightning, but since that time considerable progress has been made in the study of the phenomenon, Mr. Goodlet stating, in 1937, that "more knowledge of lightning has been gained in the last seven years than during the previous seventy." Mr. Goodlet's paper has, in turn, been added to by a further communication to the same institution. This, entitled "The Lightning Discharge," was published in the early months of this year. It takes the form of an official communication from the British Electrical and Allied Industries Research Association, and was compiled by C. E. R. Bruce and R. H. Golde.

The mechanism by which thunderclouds are electrified has been the subject of much discussion. Sir George Simpson has suggested that the separation of positive and negative charges, necessary for the process, is caused by the break-up of falling raindrops in an ascending air stream. The smaller drops formed in this way acquire a a positive charge and the negative charge is carried away by the air. The largest water drop which can fall freely in air without breaking up has a diameter of about 0.5 cm. and a terminal velocity of 8 m. per second. Sir George postulates a vertical component of wind velocity, immediately below the storm centre, greater than this figure. Drops falling into this region from the upper parts of the cloud are broken into droplets with a positive charge. These are carried upward by the air stream, coalesce, fall again, are again broken up, and so on, the final result being an accumulation of positively-charged water drops in the storm centre, the upper portion of the cloud acquiring a negative charge. One result of this hypothesis is that lightning flashes should discharge positive electricity to the ground.

Professor C. T. R. Wilson has proposed an entirely different explanation. He assumes a charge, producing a downward-directed field, already exist-

ing inside the cloud. In such a field, positive ions would move down and negative ions move up. The only ions which can exist in a condensing cloud are large ions with a mobility of about 0.0003 cm. per second per volt per centimetre. Experiment has shown that the field intensity which will produce disruptive ionisation of air containing water drops of the size encountered in clouds is about 10,000 volts per centimetre. The velocity of the large ions in the cloud will, therefore, not exceed 3 cm. per second relative to the air. This is about the speed at which a water drop 0.1 mm. in diameter will fall through air under gravity. The result is that all water drops larger than this will descend faster than the positive ions. A water drop in a field of the direction assumed will have a negative charge induced on its upper surface and a positive one on its lower. The positive induced charge on the lower side will repel positive ions which are overtaken by the drop, but will attract negative ions rising up to meet it. If the drop is falling faster than the positive ions, no positive ion can reach it from above, in spite of the negative charge on its upper surface. In this way the larger drops can collect a negative charge, the corresponding positive charge being carried to the higher portions of the cloud by the upward air stream. The initial field which is postulated for this operation must be the normal field of the earth. This is directed downward as is required by the hypothesis. Recent work has shown that the majority of lightning charges to the ground are negative.

Data on this matter have been collected by Messrs. Bruce and Golde. They show that in the tropics the proportion of negative charges to positive is much larger than is the case in temperate regions. In observations on the polarity of flashes to earth carried out in South Africa, the ratio of negative to positive was 17 to 1. In similar observations in Great Britain, Germany, Italy and Sweden the average was about 3 to 1.

It is possible that light may ultimately be thrown on this question by study of the relative meteorological conditions associated with tropical or temperate thunderstorms, the great difference in the proportion of negative discharges in the two types suggesting that temperature distribution plays a predominant part in the polarity developed. Thunderstorms which are frequent in the tropics are almost unknown in polar regions; they are commoner on land than at sea, in mountainous country than over plains, and are very rare over deserts. The absence of storms in polar regions is usually explained as being due to the dryness of the air and the impossibility of establishing the necessary vertical temperature gradient. Conditions are very different in the neighbourhood of mountains, which assist the formation of convection currents, while over land, as compared with water, the air under comparable conditions becomes hotter. These relative conditions may explain the distribution of thunderstorms throughout the world, but throw no light on the question of why negative or positive charges arise.—*Engineering.*

Municipal Loads, December, 1941

NIAGARA SYSTEM

25 and 66-2/3 Cycle

	H.P.	Population
Hamilton	159,176	163,768
St. Catharines	26,757	30,406
Trafalgar Twp.	541	V.A.

66-2/3 Cycle

	H.P.	Population
Bronte	174	P.V.
Oakville	1,204	3,869

GEORGIAN BAY SYSTEM

60-Cycle

	H.P.	Population
Alliston	402	1,437
Arthur	187	1,038
Barrie	4,123	9,521
Beaverton	262	915
Beeton	142	569
Bradford	249	1,004
Brechin	36	P.V.
Cannington	196	705
Chatsworth	103	321
Chesley	551	1,743
Coldwater	153	606
Collingwood	2,565	5,342
Cookstown	87	P.V.
Creemore	140	638
Dundalk	254	703
Durham	469	1,854
Elmvale	205	P.V.
Elmwood	79	P.V.
Flesherton	85	457
Grand Valley	132	629
Gravenhurst	1,317	2,193
Hanover	1,435	3,235
Holstein	24	P.V.
Huntsville	1,326	2,764
Kincardine	740	2,470
Kirkfield	28	P.V.
Lucknow	339	1,015
Markdale	193	795
Meaford	761	2,759
Midland	4,197	6,600
Mildmay	164	756
Mount Forest	580	1,909
Neustadt	45	468
Orangeville	796	2,608
Owen Sound	5,209	13,659
Paisley	147	727
Penetanguishene	1,002	4,076
Port Elgin	537	1,374
Port McNicoll	100	940
Port Perry	269	1,145
Priceville	10	P.V.
Ripley	105	439
Rosseau	36	310
Shelburne	244	1,018
Southampton	535	1,515
Stayner	280	1,013
Sunderland	91	P.V.
Tara	122	483
Teeswater	170	840
Thornton	26	P.V.
Tottenham	117	532
Uxbridge	374	1,535
Victoria Harbour	83	979
Walkerton	936	2,523
Waubaushene	93	P.V.
Wiarton	364	1,760
Windermere	19	118
Wingham	607	2,149
Woodville	106	425

EASTERN ONTARIO SYSTEM

60-Cycle

	H.P.	Population
Alexandria	257	1,951
Apple Hill	47	P.V.
Arnprior	1,125	3,898
Athens	134	700
Bath	36	315
Belleville	6,983	14,678
Bloomfield	105	629
Bowmanville	2,969	3,800
Brighton	403	1,556
Brockville	4,566	10,463
Cardinal	266	1,576
Carleton Place	1,717	4,275
Chesterville	327	1,061
Cobden	71	639
Cobourg	2,321	5,268
Colborne	242	942
Deseronto	177	1,300
Finch	101	347
Hastings	102	772
Havelock	156	1,156
Iroquois	265	1,068
Kemptville	388	1,223
Kingston	13,754	23,989
Lakefield	327	1,413
Lanark	103	734
Lancaster	56	563
Lindsay	3,811	7,203
Madoc	211	1,054
Marmora	155	997
Martintown	40	P.V.
Maxville	120	760
Millbrook	97	728
Morrisburg	328	1,555
Napanee	1,337	3,234
Newcastle	223	698
Norwood	169	703
Omemee	248	547
Orono	102	P.V.
Oshawa	19,617	24,938
Ottawa	34,940	145,183
Perth	1 732	4,182
Peterborough	12,610	24,017
Picton	1,168	3,582
Port Hope	2,398	4,812
Prescott	1,168	3,120
Richmond	75	409
Russell	75	P.V.
Smiths Falls	2,621	7,672
Stirling	289	981
Trenton	5,035	7,222
Tweed	266	1,246
Warkworth	86	P.V.
Wellington	177	934
Westport	106	710
Whitby	1,524	3,863
Williamsburg	123	P.V.
Winchester	339	1,059

THUNDER BAY SYSTEM

60-Cycle

	H.P.	Population
Fort William	16.438	30,317
Nipigon Twp.	218	V.A.
Port Arthur	47,134	21,284

NORTHERN ONTARIO PROPERTIES

Nipissing District

60-Cycle

	H.P.	Population
North Bay	4,620	15,797

Patricia District

60-Cycle

	H.P.	Population
Sioux Lookout	353	1,933

Sudbury District

60-Cycle

	H.P.	Population
Capreol	256	1,700
Sudbury	10,031	32,731

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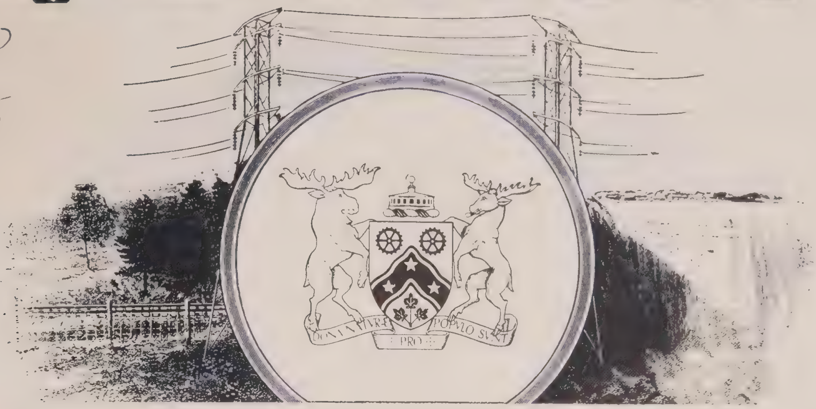

The Hydro-Electric Power Commission of Ontario

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Breakwater at Exhibition Park, Toronto, on a stormy day in February.

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Municipal Loads, January, 1942

NIAGARA SYSTEM
25-Cycle

	H.P.	Population
Acton	1,509	1,903
Agincourt	181	P.V.
Ailsa Craig	143	477
Alvinston	107	663
Amherstburg	1,052	2,755
Ancaster Twp.	414	V.A.
Arkona	65	408
Aurora	1,236	2,821
Aylmer	901	1,979
Ayr	276	768
Baden	488	P.V.
Beachville	634	P.V.
Beamsville	444	1,186
Belle River	182	852
Blenheim	561	1,844
Blyth	129	656
Bolton	211	600
Bothwell	153	646
Brampton	2,911	5,695
Brantford	20,458	31,309
Brantford Twp.	1,149	V.A.
Bridgeport	167	P.V.
Brigden	89	P.V.
Brussels	143	814
Burford	212	P.V.
Burgessville	42	P.V.
Caledonia	430	1,425
Campbellville	43	P.V.
Cayuga	157	658
Chatham	7,913	16,910
Chippawa	359	1,172
Clifford	109	456
Clinton	690	1,879
Comber	134	P.V.
Cottam	94	P.V.
Courtright	48	344
Dashwood	82	P.V.
Delaware	71	P.V.
Delhi	767	2,544
Dorchester	135	P.V.
Drayton	133	528
Dresden	424	1,572
Drumbo	107	P.V.
Dublin	41	P.V.
Dundas	2,997	5,012
Dunnville	1,439	3,870
Dutton	280	843
Elmira	877	2,069
Elora	453	1,187
Embro	110	435
Erieau	67	295
Eric Beach	10	21
Essex	598	1,854
Etobicoke Twp.	7,738	V.A.
Exeter	616	1,654
Fergus	1,326	2,732

	H.P.	Population
Fonthill	192	860
Forest	531	1,520
Forest Hill	7,986	11,757
Galt	11,548	14,286
Georgetown	1,746	2,427
Glencoe	220	726
Goderich	1,468	4,484
Granton	68	P.V.
Guelph	11,763	21,518
Hagersville	542	1,369
Harriston	409	1,326
Harrow	496	1,055
Hensall	186	696
Hespeler	2,950	2,895
Highgate	98	324
Humberstone	591	2,784
Ingersoll	3,203	5,302
Jarvis	240	536
Kingsville	785	2,360
Kitchener	27,993	33,080
Lambeth	205	P.V.
LaSalle	234	873
Leamington	1,974	5,811
Listowel	1,369	2,892
London	42,634	77,369
London Twp.	657	V.A.
Long Branch	1,221	4,200
Lucan	179	599
Lynden	101	P.V.
Markham	316	1,170
Merlin	109	P.V.
Merritton	8,296	2,656
Milton	1,430	1,903
Milverton	325	997
Mimico	2,715	7,713
Mitchell	705	1,666
Moorefield	40	P.V.
Mount Brydges	111	P.V.
Newbury	32	275
New Hamburg	632	1,446
Newmarket	1,769	3,916
New Toronto	11,882	7,175
Niagara Falls	11,093	18,770
Niagara-on-the-Lake	752	1,764
Norwich	445	1,302
Oil Springs	209	515
Otterville	106	P.V.
Palmerston	587	1,393
Paris	2,027	4,604
Parkhill	227	1,022
Petrolia	1,327	2,772
Plattsville	146	P.V.
Point Edward	1,620	1,177
Port Colborne	2,064	6,483
Port Credit	861	1,906
Port Dalhousie	859	1,595
Port Dover	436	1,864

	H.P.	Population
Port Rowan	112	706
Port Stanley	330	824
Preston	4,084	6,292
Princeton	114	P.V.
Queenston	132	P.V
Richmond Hill	477	1,317
Ridgetown	686	1,981
Riverside	1,278	5,086
Rockwood	114	P.V.
Rodney	180	763
St. Clair Beach	81	133
St. George	150	P.V.
St. Jacobs	323	P.V.
St. Marys	1,480	4,018
St. Thomas	9,201	16,362
Sarnia	11,483	18,218
Scarborough Twp.	4,623	V.A.
Seaforth	700	1,771
Simcoe	2,673	6,263
Smithville	159	P.V.
Springfield	74	395
Stamford Twp.	2,575	8,047
Stouffville	286	1,192
Stratford	7,175	17,159
Strathroy	1,408	2,806
Streetsville	194	697
Sutton	168	853
Swansea	3,634	6,375
Tavistock	618	1,080
Tecumseh	365	2,237
Thamesford	203	P.V.
Thamesville	265	826
Thedford	109	648
Thorndale	72	P.V.
Thorold	2,546	5,038
Tilbury	1,006	1,989
Tillsonburg	1,497	4,376
Toronto	364,271	649,123
Toronto Twp.	2,588	V.A.
Wallaceburg	3,177	4,783
Wardsville	41	233
Waterdown	225	892
Waterford	586	1,284
Waterloo	5,255	8,623
Watford	355	970
Welland	12,037	11,205
Wellesley	111	P.V.
West Lorne	231	783
Weston	4,781	5,784
Wheatley	183	764
Windsor	51,832	102,680
Woodbridge	627	914
Woodstock	9,057	11,418
Wyoming	89	530
York Twp.	20,871	75,842
York E. Twp.	7,964	38,054
York N. Twp.	8,749	V.A.
Zurich	116	P.V.

THE BULLETIN

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Hydro's War Task

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

ONCE again I have the pleasure of addressing the joint meeting of your two associations. Each year I look forward to these meetings as occasions for mutual benefit, affording as they do an opportunity to discuss matters of common interest informally and thereby reach a better understanding of one another's problems.

It is natural at this time that the war should be foremost in our minds and that it should be reflected in Hydro activities. War brings many responsibilities and burdens and we are not immune; but I believe I can say that no enterprise has borne them in greater degree or more willingly than our own. Although it is too early to assess our main contribution there is good reason to be proud of the part we have played, and will continue to play, in the mobilization of Ontario industry for war production.

Address before the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities at Toronto on February 10th, 1942.

When I last addressed your joint convention, in February 1940 — four months before the fall of France — I tried to apprise you of the task confronting us and of the vital contribution required of Hydro. It was clear that machines, guns, tanks, and airplanes were required in unprecedented quantities; that victory more than ever before depended upon our industrial productiveness.

I pointed out that during the two decades of peace, 1918 to 1939, the industrial use of electricity in Ontario had increased enormously; that many new factories had been established, and that upon this broad base Ontario industry was capable of rapid expansion and of mass production of implements of war, provided Hydro could supply the necessary electric power.

Two years have now passed; a rapid industrial expansion has occurred, and the end is not in sight. The demand for electric power has increased in leaps and bounds, but we have met the demands made upon us.

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Vol. XXIX No. 2

FEBRUARY, 1942

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

It is always difficult to foresee far into the future, but I warned you then that in spite of our ample reserves, the combined growth of the three Southern Ontario systems (i.e. the Niagara, Eastern Ontario and Georgian Bay systems) would probably exhaust all growth reserves by December 1941, leaving no reserves whatever. That warning was justified. Although we have increased our resources, last December we had no immediate reserves left.

Power Situation in 1938

So you may better appraise our accomplishments and our problems, let us go back to December 1938, the period of peak demand immediately prior to the outbreak of war. At that time we had a power surplus, and, as is now apparent, it was very fortunate that we did. In December 1938 the total primary demand in Southern Ontario, was nearly 1,330,000 h.p. Our total dependable power resources, including both generated and purchased power available to customers in Southern Ontario were 1,610,000 h.p. This gave us an active reserve of 280,000 h.p., or about 20 per cent, exclusive of 200,000 h.p. due for future delivery, a combined total reserve for future growth of *about 35 per cent.*

Our reserve in 1938 was such that in the early months of the year, when we lost the entire output of the Ontario Power plant which was flooded with ice and water, we were able to meet all primary power requirements without restriction.

Rapid Expansion

What is our position today? In the three years since 1938, the total primary demand in Southern Ontario has increased by 600,000 h.p., or *by 45 per cent* to 1,930,000 h.p. We have experienced both a rise in the demand for peak power and an increase in the average or continuous demand, reflecting the operation of war industries on a 24-hour basis.

With few exceptions, we have met these new demands as they came without disturbance or sacrifice on the part of any consumer. We have been able to do this by using our power reserve, by accelerating the delivery dates of purchased power, by making additional power purchases and by building new plants.

Another important factor from an energy standpoint has been the diversion of additional water at Niagara, arranged by agreement with the United States, which now permits our three large generating stations on the Niagara river to operate at almost 100 per cent load factor.

In December 1941, that is two months ago, the primary and war demands in Southern Ontario reached a total of 1,930,000 h.p. This was about 100,000 h.p. in excess of our normal dependable resources. Fortunately our generation was somewhat higher than normal due to favourable water conditions so that the maximum interruption required did not exceed 80,000 h.p. Actually on the peak day of the month it was necessary to interrupt only 40,000 h.p. for a few hours. Moreover we were able to minimize any adverse effects resulting from these interruptions by limiting them to the less essential direct customers of the Commission. But what conditions can we look forward to next winter?

1942 Estimates of Load and Resources

The Commission has taken steps to add 129,000 h.p. of new generating capacity in Southern Ontario by next December. This includes the output of the 54,000 h.p. Barrett Chute development on the Madawaska river and 75,000 h.p. to be delivered by the Beauharnois and MacLaren Quebec Power Companies. It may be possible to obtain additional purchased power amounting to 50,000 h.p., but it is probable that this will not be delivered until 1943, when 65,000 h.p. will also become available from the new DeCew development.

Thus the only safe estimate that can be made is that the capacity added in 1942 will do little more than equal the apparent shortage that existed last December, leaving the bulk of the anticipated growth, of some 300,000 h.p., to be provided for by some other means.

Given very favourable generating conditions, such as existed last year, much of the new capacity of 129,000 h.p. can be applied against new growth, but we cannot safely count upon a recurrence of those favourable conditions.

In laying our plans for next winter, we must allow for a margin of loss in generating capacity due to damage from storms, ice and other unpredictable causes.

As nearly as we can estimate at the present time the shortage in Southern Ontario will be not less than 150,000 h.p. and it may exceed 300,000 h.p.

Conservation of Electric Power

There is only one way we can meet this situation, and that is by conservation. There are various ways by which thousands of horsepower can be conserved without serious sacrifice on the part of consumers. Restrictions will not be imposed until necessary; and consumers may be sure that when they are imposed they can no longer be avoided.

Restrictions will be placed first on sign lighting, commercial and store window lighting, possibly street lighting, and certain forms of domestic use. We are studying the implications of these restrictions with the Power Controller of Canada, and a statement of methods of conserving power will shortly be issued, so when conservation becomes imperative, consumers may, by

intelligent action and without loss of time, contribute effectively to that end.

Let me say that the Commission is working in close harmony with the Dominion Power Controller, both as an electric-supply utility and as Power Controller of Ontario. We are keeping him informed of power conditions in Ontario, and we are in complete accord with the action he has taken. Enforcing restrictions is not a pleasant task either for the Commission or for the Power Controller of Canada, but it is necessary for the most effective prosecution of the war.

The Commission's duty is to assure adequate supplies of power for essential uses and, as far as possible, it will minimize inconvenience. Consumers must know not only *how* to conserve, but *when* to conserve. The members of these two Associations know that the most well-intentioned sacrifices may count for little if they are not made at the right time. Let no consumer think that the amount of saving he can make in the home, store, or factory is insignificant and unimportant. It is the saving of thousands of consumers in aggregate that counts. The additional electric power made available by all consumers checking waste and curtailing non-essential uses may mean the difference between a sufficient and an insufficient power supply for war industries and vital uses.

Additional Electric Power Necessary for Expansion of War Industry

As you know, electric power, is a vital sinew of war. Like most of our Allies, Canada entered this war unprepared in many respects, but fortunately, it had large developments of hydro-electric power. Canadian industry has been able to produce more speedily, more efficiently, and in greater quantities because of access to hydro-electric power requiring a minimum of labour to produce it. In a real sense we have enlisted on our side a vast labour force of kilowatt-hours, turning out planes, tanks, and guns, tirelessly and ceaselessly, 24 hours a day. That The Hydro-Electric Power Commission has been able to supply Ontario industry with billions of kilowatt-hours, yet has engaged not a single man in the extraction of coal from the earth, or a single car to transport that coal, has made our war contribution more effective and much larger than would otherwise have been possible.

Now we have reached the end of our ability to supply fresh demands from existing plant and equipment. Our present capacity is fully employed and we shall have to conserve. But the power requirements of war industries cannot be met entirely out of the savings of consumers, any more than civilian conservation of aluminum will release sufficient aluminum for the required production of planes. The demand is too great. Additional capacity must be provided. An imposing group of factories is being built, and will continue to be built, in Ontario, and they are relying on this Commission to supply them with electric power. To fail them in this would lead to an emergency so critical as to seriously hamper, if not wreck, the whole production programme. Many persons demanding a total war effort are critical of hydro-electric expansion on the grounds that it would use men and materials. Strangely enough, they are opposed to doing something by which, in the end,

that total war effort can alone be achieved.

There are, indeed, strong inducements for the Commission to make use of what capacity it now has and avoid *all* new commitments, however urgent and necessary they may be, for when factories turn from the manufacture of armaments we may experience a decline in the power demand of six or seven hundred thousand horsepower. This means that until the peace-time load takes up this slack we shall have to meet the carrying charges on a considerable quantity of idle plant by withdrawals from our reserves.

While such a course might be desirable based on purely financial considerations, I do not take such a narrow view of our responsibilities; and I am sure you do not approve a course so dangerous to our country's future. We do not know what fresh power demands will be made upon us. They depend on the duration of the war. It may be two years or ten years; I do not embark on prophecy. If we were thinking only of ourselves we might gamble on a quick victory, and on squeezing enough out of civilian consumption to make good, partially at least, the deficiencies of our war industries. But having regard for our cause and our responsibilities we cannot do so. In no quarter is there assurance that the war will be very short or that we can meet fully the demands of war industry out of the patriotic savings of consumers. We have no alternative but to expand.

Quality of Service Affected

The Commission has always regarded it as a fundamental obligation to meet all the demands for electric power made upon it by the municipalities and its other direct customers. But as we have seen, in this war, we cannot do so. The rapidly growing load has already overtaken—yes exceeded—our dependable power resources. Naturally, in these circumstances, some impairment in the quality of the service we can give is unavoidable. As the war progresses, it is probable that we will have to depart more and more from the high standards we achieved in peace-time. Already we have been forced to connect a greater number of customers and larger blocks of load to common circuits than we did before the war. You cannot overload lines and other apparatus without some sacrifice in quality of service.

Service will also be affected by the scarcity of materials, by the lack of skilled engineers, linemen, and operators and by the loss of a number of our employees to the armed forces. We will have a limited amount of new material and equipment to maintain our facilities in a satisfactory working condition. Our difficulties will be accentuated, too, by the fact that much of the work of the Commission is highly specialized and requires experienced men of a type much sought after by the Department of National Defence and war industries. These conditions place a heavy burden on the supervisory staff. Responsibility must sometimes be delegated to men who do not possess the experience or mature judgment that is most effective in dealing with complex problems. Although we are not looking for serious trouble it is well that you should know the difficulties under which we are now operating.

Scarcity of Material

I have pointed out that we cannot supply all new war demands unless we expand. All our efforts to do so, however, face this special difficulty: modern warfare requires a gigantic flow of aluminum, copper, steel, rubber and other products which are the material requisites of any programme of electric power expansion. The intensification of demand for these products has given rise to serious shortages and necessitated strict curtailment of their use for all purposes which do not have a definite bearing on the nation's war effort.

This means that materials are not available at the present time for an expansion of electric power facilities to meet non-essential demands. It means too that improvements which are not deemed vital to the supply of adequate service must be postponed. The installation of fine voltage regulation devices and high safety factor and standardization designs must be deferred until the end of hostilities. By doing this we will ease not only the current short condition of metal production, but accumulate a backlog of improvements which may be undertaken when the war is over to bolster employment.

Helping the Production Programme

The development, production and supply of electric power must, of course, engage most of the thought and energies of the Commission and its staff, but we early made it clear that we would co-operate in every way possible to increase war production and hasten the day of ultimate victory. In line with this we have placed engineering designs and technical assistance at the disposal of the Dominion Government and war industry. We have given help in designing and constructing distribution systems for airports and war industries. We have undertaken to test and inspect war materials for the Canadian and British Governments. Members of the staff have been loaned to the Dominion Government and the University of Toronto to carry out special research work. Our machine shops for several months now have been producing tools and equipment for war industries under what is termed the "Bits and Pieces Programme". This work ranges from the production of ½ in. studs and turning the noses on armour piercing shells to the machining and boring of 9-ton castings for marine engines.

Many of the Commission's employees are now serving in the active armed forces or in the reserve army, particularly the Royal Canadian Engineers. Others have become officials and instructors in the Civilian Defence Corps.

Practically all members of the staff are purchasing war saving certificates or bonds, making monthly subscriptions to charities and giving willingly of their time and energies to the Canadian Red Cross and other patriotic societies.

Post-War Problems

While our main attention is focussed on the war, we should not ignore the many problems which will confront us with the coming of peace. Until 1930 the Commission was not seriously concerned with the problems of declining demand: growth was fairly regular; in the Niagara system the primary power demand increased on the average by about 10 per cent per annum. But all that is now changed. The experience of the 1930's does not justify complac-

ency. We must face the fact that the power load is not going to grow year after year in an orderly fashion, that there will be "ups" and "downs" and the impact of those fluctuations will be very serious unless we take steps to minimize their effects.

This Commission has always considered the risk of power shortage, to be much more serious than over-provision. But we see, today, that our efforts to avoid this greater risk have not altogether succeeded in eliminating it. In war the abnormally rapid growth in load and the scarcity of men and materials make the task of meeting all demands for power progressively difficult.

Consider now the other side of this problem. We must expect when this war is over and victory is won, a sharp reduction in war loads, and we cannot hope for an immediate expansion of other loads to fill the gap. In short, when the war ends we will have considerably more power on hand than we can put to economic use. This will involve a serious financial burden. Our costs, for the most part, are fixed. Leaving out rate stabilization, about 63 per cent of the Commission's revenue goes for interest and purchased power; 17 per cent for depreciation, contingencies and sinking fund; and only 20 per cent for maintenance and administration, including taxes and materials. The possibilities of cutting costs are very limited and we must look largely to our reserves to tide us over the post-war slump.

There are some people who take the view that there is an economic law that war must inevitably be followed by protracted hard times and poverty. There is no such law. Whether the post-war slump will be long or short depends upon the measure of common sense that we apply to our national and international problems and the scale upon which we deal with them. But an initial period of dislocation, while producers change over from war to peacetime production, can hardly be avoided. The Commission's direct war industries load at the present time is about half a million horsepower, and may reach a million or more, before victory is secured. A recession in this load must be expected.

Many of you will recall that during four years of the 1930 and 1935 depression the Commission withdrew nearly 13 million dollars from reserves in the Niagara system to avoid raising the cost of power. Although the circumstances are dissimilar in many respects, withdrawals after this war from our reserves at a rate of 6 million dollars a year until the transition period is past and full recovery is achieved cannot be ruled out as impossible, or even improbable.

I have tried to tell you what we have accomplished and of our immediate plans for the future. I have tried to show you the enormity and difficulty of our task. Our role is an important one. The Hydro enterprise exercises a telling influence on the direction of war as of peace and I am sure that, as in the past, it will have the best devotion and co-operation of the members of these two Associations.

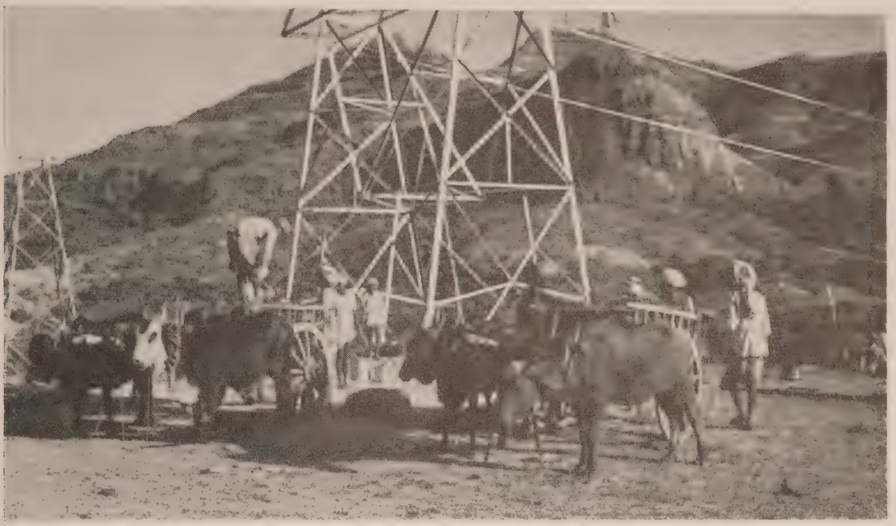
View along one of the long spans across valleys which are from 4,000 to 5,000 feet in length.

Asiatic Transmission Line Construction

THE illustrations shown herein indicate methods of 110 kv. transmission line construction in a mountainous district of India where railway or other means of convenient transportation are not generally available, and where human labour is cheap. The photographs were secured by J. P. King of Aluminium Union Limited (Canada), who superintends the erection of steel reinforced aluminum cable for power transmission in many parts of the world, during a considerable period on this job. Copies were supplied by the Aluminum Company of Canada, Limited.

At Right:

Looking down mountain side and penstocks towards a power house the hydraulic head for which is about 3,000 feet.



Equipment is transported on ox-carts by local cattle.

The total length of the line is approximately 32 miles, being a tie line between two hydraulic generating stations. There are 14 miles of 3 phase, 397,500 cir. mils a.c.s.r. and 18 miles of 250,000 cir. mils stranded copper single circuit line. It is carried on steel towers of a heavy type, with heavy

Man power pulling a.c.s.r. cables to tension. In some cases there may be as many as 150 men in a gang.

This might have been pushball in England a few years ago. Actually there is a reel of cable in the centre of the group. It is being rolled on to a reel stand so that the cable can be unwound from the reel.

duty suspension type insulators. The conductors are arranged horizontally, separated 25.5 feet. There are two stranded steel ground wires. The normal span is 1,250 feet and the maximum span 4,200 feet. Maximum tension is 10,000 pounds. The line was designed to carry loads of the order of 25,000 h.p.

One of the illustrations shows penstocks leaving a dam and being carried down the mountain towards the power house, where there is a hydraulic head of about 3,000 feet. There is no particular river or watershed to give a water supply. The dam, built at a suitable location, catches and stores rain water from a quite small catchment area to be used as required.

All transportation was by ox teams and all work was done by either men or oxen. In some cases as many as 150 men were used as man power to pull in one stretch of cable over long spans up to the order of 4,000 to 5,000 feet. Wherever possible local oxen were used to pull out the cable.

Such construction methods are natur-

The families of the men move along with construction men from camp to camp.

ally slow, and it is the custom for the men to take their wives and families along with them, moving from place to place as the work progresses.

New C.E.S.A. Electrical Standards

The Canadian Engineering Standards Association has just issued the following nine Approvals Specifications under part II of the Canadian Electrical Code, the requirements of which must be met in order to obtain C.E.S.A. approval of the electrical devices concerned.

C22.2 No. 5 — 1942 — Service-Entrance and Branch-Circuit Breakers (Second Edition).

C22.2 No. 9 — 1941 — Electric Fixtures (Second Edition).

C22.2 No. 11 — 1942 — Fractional-Horsepower Electric Motors for Other Than Hazardous Locations (Second Edition).

C22.2 No. 21 — 1941 — Cord Sets (Second Edition).

C22.2 No. 54 — 1942 — Integral-Horsepower Electric Motors for Other Than Hazardous Locations.

C22.2 No. 55—1942—Snap Switches.

C22.2 No. 66 — 1942 — Specialty Transformers.

C22.2 No. 67 — 1942 — Portable Electric Vacuum Cleaners.

C22.2 No. 68—1942 — Motor-Operated Appliances—Domestic and Commercial (Fractional Horsepowers).

The Metal Situation

By George C. Bateman, Metals Controller of Canada

I AM pleased at the opportunity of talking to you because this group, representing as it does the electrical industry, the public utilities and the municipalities, it is the largest consumer of copper and its alloys for domestic purposes.

I believe there are very few people today who really appreciate the serious situation that exists in the supplies of raw materials and so I am glad of the opportunity of telling you something of our problem in the hope that I may enlist your help and cooperation. This is essentially a mechanized war and the demand for metals for tanks, ships, guns, shells and airplanes is greater than at any previous time. You will remember that in the last war before some of the great advances the guns stood for miles, almost hub to hub, and fired steadily for perhaps 48 hours, yet today the British demand for copper is more than 2½ times what it was at the maximum of 1914-1918 requirements.

There is a general belief that Canada has plenty of metals, and a belief which is not so general, although widespread enough to be dangerous, that while it may be necessary to conserve our supplies, it is really not necessary to carry this to the point where it hurts. The first part of this statement is true but the second part is most decidedly not.

In one sense, Canada has plenty of metals and it is, in fact, the greatest exporting country in the world of non-ferrous metals. Our production is far in excess of our own requirements. For example, we are not consuming more than 5 to 6 per cent of our production of aluminum or 5 to 6 per cent of our production of nickel. I doubt if, at the maximum of our war demands, we can use more than 50 per cent of our zinc or 60 per cent of our copper.

Now, if we looked at these metals only from the point of view of Canadian supply and Canadian requirements, there would, of course, be no problem as we have much more than we can use ourselves. However, we can not and must not look at it only from the Canadian point of view. We must look at it from the point of view of the overall supply and the overall requirements of the United States and the British Empire, and there the position is by no means so favourable. In fact it is decidedly unfavourable and

Address to the Electric Club of Toronto, the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities at Toronto, February 11, 1942.

there is a serious deficiency in all of the primary non-ferrous metals and in most of the strategic minerals.

In the face of such a situation, Canada has no other option—and this is a position we have taken for a long time—than to drastically curtail the non-essential uses of metals in order to make the maximum amount available for the war effort. In fact, before we get through, we will have to curtail some of what we consider essential uses and perhaps some of the war uses in order to provide for the most pressing of our war needs.

Now, as I said before, our own position in the primary non-ferrous metal field is favourable but there are other metals and minerals less well known but equally important which we do not produce and which we have to import. The principal ones are chrome, manganese, tin, and tungsten. You may think you are not particularly concerned with these but if you do, you would be wrong.

None of the fabricated products which you use can be made without steel and steel connot be made without manganese. In fact, quite apart from manganese steels, each ton of steel produced requires an average of about 14 pounds of manganese and so far we have been unable to find any important supply of manganese ores in Canada.

I wish I had a map of the world with me because the story of our mineral supplies is a lesson in geography, and it is much easier to follow it with a map. However, as there is none, I shall try and do the best I can without it.

Now, there is lots of manganese in the world, but not much of it in North America, and practically none in Canada. It is not a problem of ore supply so much as it is of transportation and shipping. The chief centres of supply are Takoradi in the Gold Coast of Africa, Brazil, Cuba, Russia Karachi in Baluchistan and the east coast of India. Brazil and Cuba may be considered as a United States preserve. Certain supplies are drawn from India but Canada and the United Kingdom are largely dependent upon the Gold Coast and, in the absence of a map, I may tell you that this is not far to the south east of Dakar. Now, if the Germans were able or were permitted to seize Dakar, our supplies of this essential material would be seriously jeopardized.

Chrome is one of the essential alloying materials in the production of special steels, and you in the electrical industry are familiar with its use for heating elements. At the present time, Canada is not a producer of chrome although we hope to provide part, at least, of our requirements. Supplies are, or were, drawn principally from Rhodesia, South Africa, the Philippines, New Caledonia, India and Turkey. The Philippines, at least as far as supplies of chrome are concerned, is gone. New Caledonia is definitely in the danger zone and Turkey is an uncertain quantity and our chief source of supply is Rhodesia and South Africa. As with manganese the enemy occupation of Dakar would endanger supplies from Rhodesia and South Africa.

Manganese and chrome are both used principally in the production of ferro alloys and, as an evidence of the increased demand, I may tell you that while before the war we used approximately 30,000 horsepower in the production of ferro alloys, today we are

using well in excess of 200,000 horse-power. The greatly increased need for ores has correspondingly increased the need for shipping which, in itself, also represents one of the serious shortages.

Tungsten is used primarily in the production of high speed steels and, as such is important in your manufacturing processes. You are perhaps more familiar with tungsten as the element in incandescent lamps. Some tungsten comes from South America, some from the United States, some from Australia and New Zealand, some from Portugal and Malaya, but the principal source has been China, with the product coming out over the Burma Road. This is one of the reasons why the Far East is important for us, because, with greatly increased demands, tungsten is definitely short and our production in Canada is negligible.

There are many phases of modern warfare other than actual fighting and one of these is in the field of economic warfare, part of the function of which is to acquire supplies which might otherwise be available to the enemy. Sometimes this gives the seller a golden opportunity and recently I paid $1,000 a ton for some Portuguese tungsten for which the British had paid $22,000 a ton to keep it away from the Germans. I am told that the competition was so keen that the Germans approached the British to see if they would not put a price ceiling on tungsten in order to prevent such ruinous competition.

Tin is something you are all familiar with. Its principal uses are for tin plate, for bearing metals and for solders and it has a very wide application in the electrical industry. Approximately 75 per cent of the world's tin comes from Malaya and the Dutch East Indies, with Bolivia next in importance, and some also coming from the Belgian Congo. Now, as you know, Malaya is lost, and the Dutch East Indies is in serious danger. For a time during the fighting in northern Malaya the name of Ipoh figured very largely in the news as the scene of a determined resistance. To me it was more than the centre of serious fighting it was also the centre of a great tin mining area. To you perhaps the loss of Penang may have meant the loss of an important naval base, but to me it meant more, it meant the loss of the greatest tin smelter in the Far East.

Now, let us look at this picture realistically. If the British have done as was expected of them, they will have adopted the scorched earth policy, and the tin dredges will have been destroyed. If, for some reason, they failed to do this, we can be sure the Japs won't fail to destroy the dredges when they are finally driven out. It will probably take from a year to a year and a half to build and install new dredges, so that even if the war were to end this year, it would be well on in 1944 before we could expect any considerable shipments of tin from Malaya and in the meantime we do not know just where or in what quantity further supplies will be available. Under these circumstances, what are we going to do? There is only one answer, cut consumption to the minimum and if you think you cannot get along without tinned wires, without high-grade babbits, and without high tin solders, you will, in the great majority of cases, have to change your mind because the tin won't be avail-

able. To ensure this, we are taking over surplus stocks and putting them in a government warehouse under lock and key and it will need a good reason to get it out.

With chrome and manganese it is largely a case of shipping; with tin and tungsten it is a question of scarcity; but the answer is the same in both cases. Intensify our search for domestic supplies, acquire stocks whereever possible, and exercise the utmost degree of conservation with the supplies we have.

Now, I would like to turn back to the primary non-ferrous metals with which you are more familiar and which you are more accustomed to use, aluminum, nickel, lead, zinc and copper.

You have all seen the newspaper reports of the tremendous expenditures for war materials to be made in the United States. You have all heard of the Victory Programme in that country but so far, no one has been able to convert those expenditures and that programme into terms of the raw materials on which it is based. All we can say at the moment is that it will add fresh burdens to an already overburdened production schedule. When you stop to realize that one large bomber may take 85,000 pounds of aluminum in the form of sheet alone, you will see why an increase of a thousand per cent in aluminum production over pre-war may not be too much, and that is what plans call for. The principal requirements for aluminum are raw materials and electric power. The raw materials, that is the ores, are obtained from British and Dutch Guiana in South America and shipping is subject to the hazards of submarines on the Eastern Atlantic coast. Power is definitely short which is the reason why you will see some of the new plants built around some of the large cities in the United States where power can be taken away from other uses.

Nickel production today is approximately seven times what it was in 1914, but today the estimated deficiency is twice as much as the total production in 1914. Canada provides about 95 per cent of the nickel available to the Allies with most of the balance coming from New Caledonia which, as I said before, is now in the danger zone. Fortunately, most of the production is in a safe area but there are limits to our ability to increase our output to any great extent.

A few months ago I estimated the deficiency in zinc at approximately 200,000 tons. I was in Washington about that time and was told that in spite of this large shortage the zinc position was somewhat easier because there was not enough copper to alloy with it. A few days ago I read in *Time* that zinc requirements in the United States were now estimated at 1,450,000 tons per year. Production is about 1,000,000 tons or a little less. Where is the balance to be obtained? I don't know. If requirements of zinc are 1,450,000 tons that means that requirements for copper are over 2,000,000 tons, and I have heard estimates much higher than this. United States Copper Production is around 1,000,000 tons and that of South America is perhaps 600,000 tons but this South American production is also subject to shipping hazards. Here again there is a great deficiency and I do not know how it can be met. The deficiency may be

greater than we estimate because, as I said before, we have not yet been able to convert the Victory Programme into terms of raw material requirements.

Perhaps some of you may think that your requirements are so small in comparison with these large tonnages that the war effort could not be effected one way or the other if you were given all you asked for. For the individual this is probably quite true but these individual requests have to be multiplied by thousands and in the aggregate they amount to large figures. In 1940 for example the electrical industry as a whole used 35 to 40 per cent of all the copper consumed in Canada. Under present conditions the percentage is probably smaller but the tonnage is greater on account of the great expansion of war plants. The demand for electrical uses comes into competition with more direct war uses such as shells and ammunition and you can judge how severe this competition is when I tell you that our production of brass has been increased by 1000 per cent and our requirements are not yet satisfied.

Lead, so far, is the least scarce of the metals, but with increased war demands and the substitution of lead for copper and brass, consumption continues to increase and this metal will also have to be rationed. Our own domestic consumption is now two to three times what it was at the outbreak of the war.

Canada cannot do a great deal more in the production of nickel, copper, lead and zinc. Our mines are working under forced draft. Our smelters are working practically to the limit of their capacity and, in some cases, to the limit of the power available.

We have been too apt to talk glibly about our illimitable mineral resources. In talking this way we have just been fooling ourselves. Our resources are far from illimitable and I shudder to think of the toll that is being taken of our vanishing ore reserves and of the effect that this may have on the future life of these mines. If you were to ask me where in Canada we could quickly provide new and important supplies of metals I would have to tell you I do not know. We could increase our production of zinc concentrates for shipment to United States smelters but I cannot tell you where there is any substantial amount of lead available and the total tonnage of copper in the unworked copper properties in Canada which I know of would not represent more than three to four months' production at our present rate. This is not an optimistic picture.

What, then, is the answer? How can these deficiencies be met? If we had time, we could do it easily because the United States and the British Empire, between them, control 75 per cent of the mineral wealth of the world, but we haven't time. We must try and do in one, two or three years, what the enemy has taken many years to do.

Mine production, already at a high level, cannot be increased overnight. We need new mines which we haven't got, and any large programme, requiring mine development, milling and smelting facilities, would probably take years. We haven't got these years, and if we wait for them, we may be lost.

Our need is now, and the only answer is to go to those places where the material is being used and take it away. We must do this, regardless of its effect on our national economy, and, in doing

so, we need the understanding and the help of men like yourselves. I heard recently of one municipality with its warehouses stocked to the roof with copper pipe and scarce metal products of that sort. The man who piles up unnecessarily large inventories under today's conditions is not showing what, in ordinary times, might be good business judgment—he is doing a disloyal act and sabotaging the war effort.

You may ask what you as individuals can do. You can utilize existing plant and equipment to the best possible advantage. You can defer any but the most essential construction. You can rebuild old equipment instead of buying new even although it may not be as efficient or as economical. You can put unused equipment on the market and you can go over your inventories with a fine toothed comb to see that they do not contain obsolete supplies and are not larger than they should be. You can go through your scrap piles to see what useable material they contain and in doing so you will probably surprise yourselves and you can collect, segregate and dispose of every pound of scrap metal. You can and you should be the metals controller of your own operations because unless the initiative comes from the top you cannot expect results.

Restrictions and curtailment must be continued. They must be made more widespread and more severe because of the scarcity of essential materials. If we cannot fight and win this war and, at the same time, carry on a normal way of life, there can be no question as to which must be sacrificed, and that normal life must temporarily disappear to be picked up again as best we may after the war is over.

Repairing Hot Water Tanks

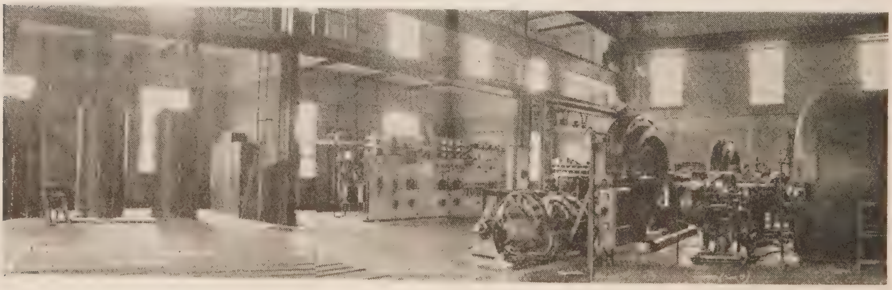
The following suggestion for repairing hot water tanks is timely, as it is now almost impossible to obtain new boilers. We believe it will be of interest to municipalities as one method of repairing an old tank.

* * * *

With the present shortage of water heater tanks the following method of repairing without removing the boiler has been found effective.

The hole is enlarged with a standard reamer. The tang of a heavy file is then used to enlarge the hole sufficiently to permit the entrance of a tap. The use of a file for this purpose builds up a burr of metal around the hole which increases the portion to be threaded.

The hole is taped with ¼ in. pipe thread and a standard plug is installed using hemp in threads with plenty of red or white lead.—R.E.J.



Better Tools For Hydro Rural Lines

By E. R. Lawler, Assistant Engineer, Municipal Engineering Department, and Chairman of Live Line Clamp Committee, H.E.P.C. of Ontario

SYNOPSIS

On June 23, 1941, the operating procedure in certain rural power districts in Ontario was changed, and linemen commenced doing certain work with rural distribution lines alive which formerly had to be dead. The design and production of special tools and pole hardware preceded this change, thereby making possible the use of live line tap clamps. This has resulted in a reduction in the number of interruptions to the service to rural consumers. In this paper the author summarizes the results obtained, and then describes in detail the tools and pole hardware and the reason for their adoption. The proper instruction and the training of linemen is stressed in order to prevent accidents.

THOSE engaged in the operation of electrical distribution systems have two thoughts constantly in mind: the one is safety to the workmen and the other is service to the consumers.

Originally the service in rural power districts was for lighting and a few appliances, therefore, the consumers, when requested, gave their consent to pre-arranged interruptions during the day time. As a number of serious accidents had occurred to linemen while working on live lines and as interruptions were granted by the consumers, the practice has been for the last several years that no work was done on live distribution lines. However, labour-saving electrical appliances and motors have been installed by the consumers in such great numbers and for such a variety of uses that interruptions to service are now a decided inconvenience, and in some cases cause a monetary loss.

In order to improve conditions, the Chief Municipal Engineer in June 1939 appointed a committee to study the question of using live line tools for the installation of live line clamps and doing a limited amount of work with the rural distribution lines alive.

Presented to the Association of Municipal Electrical Utilities at Toronto, February 11, 1942.

Summary of Results as at December 31, 1941

A number of new tools and items of pole hardware have been designed and produced.

A set of rules governing the use of these tools has been compiled and printed under the direction of the Safety Rules Committee.

Changes in the distribution standards for rural power districts have been made to incorporate live line clamps and facilitate the use of live line tools and new pole hardware.

In the rural power districts, where the distribution voltage is not higher than 4600-8000 volts, all work on primary services and transformers is done with the primary lines alive. Connections of primary services and transformers are made with live line clamps.

One hundred and ninety-two (192) linemen and line foremen have been instructed, trained and authorized to work using the new tools in seventy (70) rural power district operating centres. Training of men is proceeding in five (5) additional operating centres.

One hundred and thirty-two (132) complete sets of these special tools are in use in these seventy-five (75) rural power district operating centres.

All transformer work and the erection of buck-arms for primary services is now carried on with the line conductors alive, where formerly they had first to be de-energized.

Interruptions to service have been reduced, thereby improving the service to the consumers.

More economical operation has resulted, due to a reduction in truck mileage and labour formerly required to drive to and fro to open and close line sectionalizing switches.

* * * *

When the Committee began the investigation they found that the then available equipment did not fulfil the requirements of the Commission.

While it had long been the practice in certain of the larger municipalities to work on live lines with rubber gloves, line hose and guards, in general it had not been considered safe to work in this manner on voltages higher than 4000 volts.

When using rubber gloves, line hose and guards, the lineman must be above, or on the level of live conductors. In such a position, a false move or an accidental slip by the workman is liable to bring him into contact with a live conductor.

What was required was a working procedure and corresponding tools which would apply not only to four thousand (4000) volt lines, but to 4600-8000 volt, and possibly at a later date to 6900-12000 volt. To satisfy this requirement, new tools had to be designed and produced.

The miles of line and number of transformers in the rural power districts at the various voltages are shown in the tabulation:

RURAL POWER DISTRICTS AS AT OCTOBER 31, 1941

Voltage	Miles of Line	Approximate Number of Transformers
2300 4000 2300-4000	12,416	41,000
4600-8000	5,825	17,500
6600 6900-12000	1,010	3,600
	19,251	62,100

On Plate 1 is shown the new standard method of erecting a transformer with single-phase, grounded circuit, and line neutral on the crossarm. For grounded circuits with line neutral on a bracket and for ungrounded circuits, the standards for transformer erection are similar to this one.

This was made possible by the use of live line tools and a type of tap clamp which was not before used in the rural power districts.

Due to the substantial distance between farm consumers, the majority of transformers supply only one con-

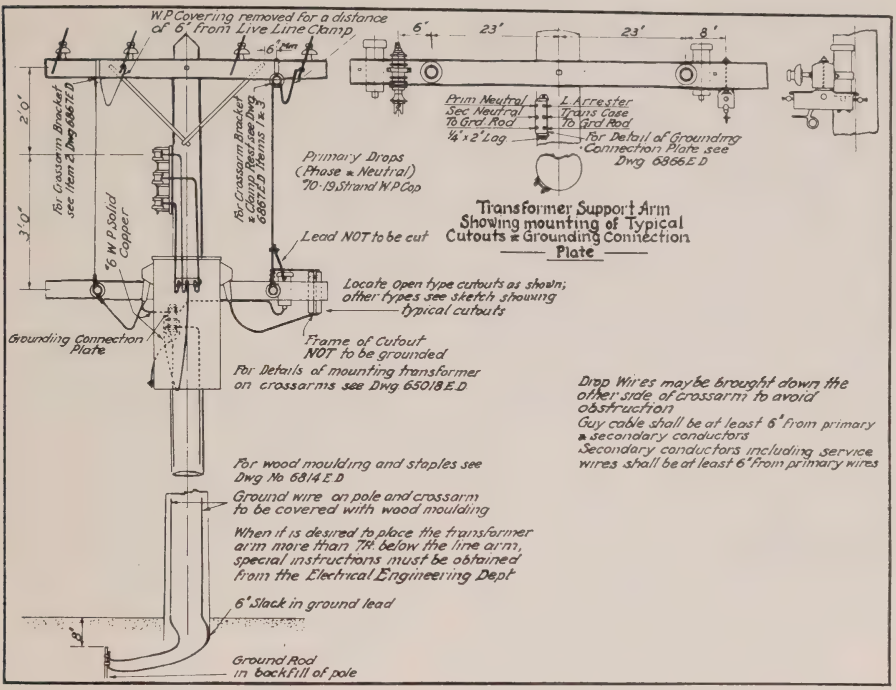


Plate 1—Method of erecting transformer, single phase, grounded circuit, neutral on crossarm, live line clamp.

sumer. This necessitates a great number of small transformers which are located on the poles of the main line or on private property at the end of primary services. To connect these transformers or their primary services to the main line, live line clamps are now used and the operation is performed with the main line alive. New pole hardware and special tools make it possible for the lineman to do this from a position on the pole a safe distance below the live conductors and apparatus. In this position he cannot contact anything alive with any part of his body.

Live line clamps and operating sticks had been available for some time, but in the use of them the clamp, after being disconnected from the line wire, had to be removed from the stick by hand. This procedure is dangerous, since under some conditions the first clamp disconnected from the line remains alive until the second clamp has been disconnected.

It was necessary to provide means, other than by hand, of removing these live clamps from their operating sticks. This was accomplished by a crossarm bracket and a clamp rest, shown on Plates 2 and 3. With the spring head and standard switch stick the crossarm bracket assembly can be erected on, and removed from, the line crossarm by a lineman standing at a low position on the pole.

A later development is the crossarm bracket and the drop wire support shown on Plates 3, Figs. 1, 2 and 3.

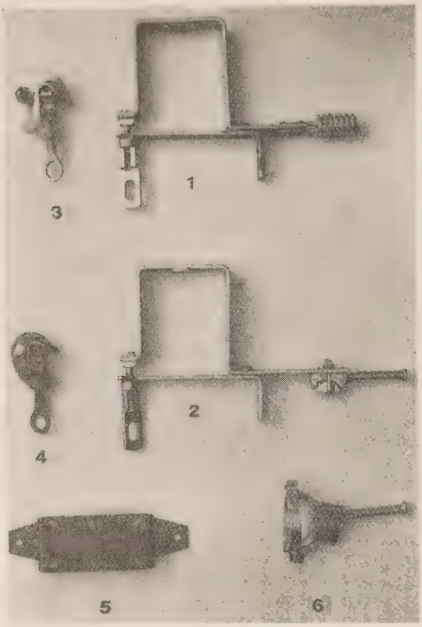


Plate 2—R.P.D. live line material.

Fig 1—Crossarm bracket (phase).
Fig. 2—Crossarm bracket (neutral).
Fig. 3—Live line clamp, screw type aluminum.
Fig. 4—Live line clamp, screw type bronze.
Fig. 5—Grounding connection plate.
Fig. 6—Clamp rest.

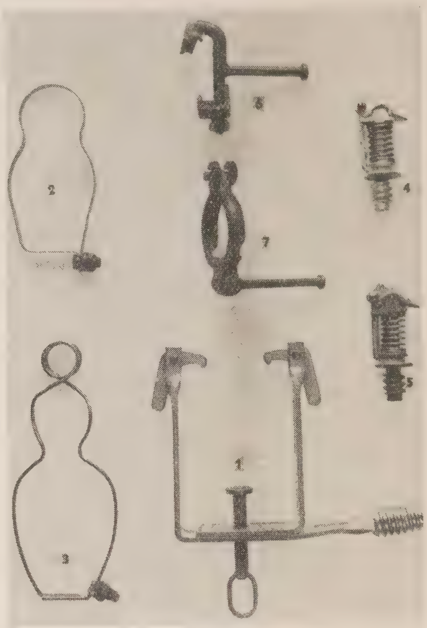


Plate 3—R.P.D. live line material.

Fig. 1—Crossarm bracket.
Fig. 2—Spring drop wire support, stainless steel.
Fig. 3—Spring drop wire support, copper weld.
Fig. 4—Spring type live line clamp, aluminum.
Fig. 5—Spring type live line clamp, bronze.
Fig. 6—Clamp rest with rest pin at centre of the insulator.
Fig. 7—Clamp rest with rest at bottom of the insulator.

The clamp rest or the drop wire support provides a support for the primary drop wire to the transformer. This relieves the live line clamp from supporting the weight of the drop wire.

Previously the weight of this drop wire was supported by the live line clamp attached to the primary line wire. Some of the reported loosening of clamps may have been caused by the swaying of these drop wires by the force of the wind.

Live Line Clamps

After considerable testing in the laboratory and in the field on available clamps of this type, a design was completed of a screw-type clamp, Plate 2, Figs. 3 and 4. This design was modified and the clamp, Plate 4, having an elliptical eye is the one now in use. A spring-type clamp, Plate 3, Figs. 4 and

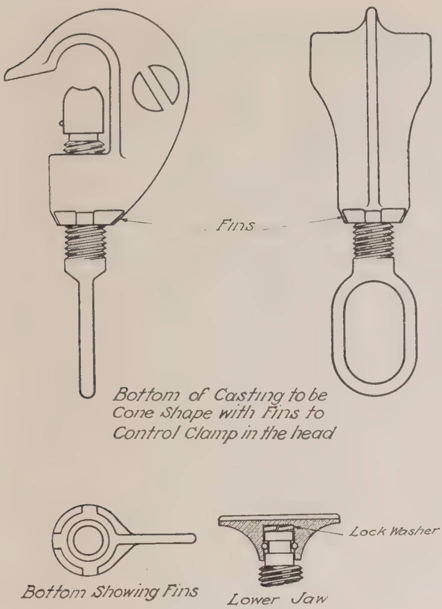


Plate 4—H.E.P.C. No. 40 live line clamp.

5, was designed and a small number produced. These are being tested at the laboratory and in the field. A small number of the screw-type clamps were made of aluminum, but due to the necessity of conserving this metal these were discontinued, and all clamps now being used are of bronze. No action between the clamp and the conductor is expected, due to the conditions under which these clamps are used and the small amount of current they are required to carry. These clamps are so designed that a lineman cannot distort them by the force used when fastening them tightly to the conductor.

Samples of these clamps were given the "weatherometer" test which simulated line conditions, consisting of temperature cycles approximately 50 to 120 deg. fahr. and alternate wet and dry conditions every half hour. All clamps were cleaned and placed on new No. 4 a.c.s.r., not cleaned. The following is an excerpt from the laboratory report:—

RESISTANCE OF CONTACT IN MICROHMS

	As first assembled	After 24 hours in the weatherometer
Bronze spring clamp	500	4000
Aluminum spring clamp	300	1000
Bronze screw type clamp	100	120
Single bolt parallel groove aluminum clamp	100	138

It is generally accepted that one requirement of a good conductor joint is a reasonably constant electrical resistance during normal life. In this respect, the screw-type clamp appears to be superior to the spring-type. The foregoing test data are not considered sufficient to condemn the use of spring-type clamps. It is difficult to predict from these tests just how serious the trouble may become under actual line conditions. For instance, conductor vibration might provide a self-cleaning action at the contact surfaces.

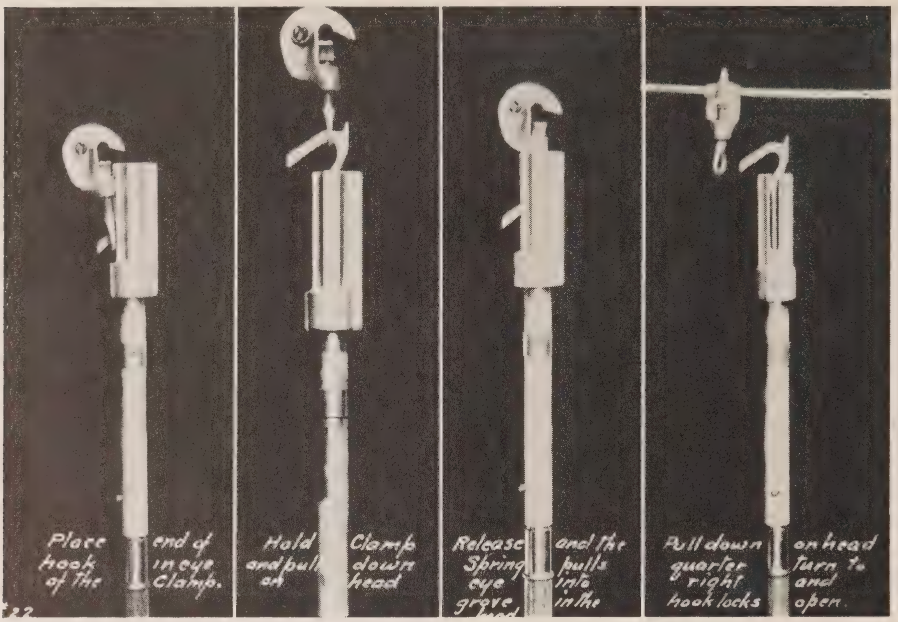


Plate 5—Spring head, simple to operate.

Samples of these clamps were subjected to vibration to give an indication of the results which could be expected under actual service conditions. Two clamps were fastened to a one hundred and forty foot span of 3/8 in. steel cable which was under test with a vibration generator. From one of the clamps the lock washer was first removed. Tension in the span was 3000 pounds. The clamps were located at a point in the span to simulate conditions in service. The span was vibrated during office hours each day at the rate of 20 cycles per second. After vibrating for approximately 17 million cycles, the clamps were examined and no loosening of either clamp had taken place.

Switch Sticks

For a number of years all the rural power districts have been equipped with switch sticks for operating fuse switches and for grounding de-energized lines. Means for carrying these sticks had been provided in the Commission's trucks. It was the Committee's desire not to discard all this equipment, and since the handling of heavy tools and fittings was not contemplated, these sticks were retained and the new tools adapted to them.

Spring Head, Plate 5

This most important of the new tools made possible the use of other new tools and fittings. Its weight is two and one-half pounds and its length is fifteen inches. It was made small in diameter so that the clamp can be seen by the lineman when being placed upon the line wire. This head is simple to operate and affords complete control of the clamp at all times. It cannot be locked open to release the

Plate 6—R.P.D. live line tools.

Fig. 1—Spring head.
Fig. 2—Wire cutter.
Fig. 3—Block hanger.
Fig. 4—Block spud.
Fig. 5—Tie wire remover.
Fig. 6—Cutout grounding clamp.
Fig. 7—Cutout grounding plug.
Fig. 8—Live line tool box.
Fig. 9—Switch stick 5 ft. long.
Fig. 10—Grounding head.
Fig. 11—Cutout head adapter.
Fig. 12—Line grounding clamp.

clamp until the clamp has been tightened on the line wire or clamp rest.

BLOCK HANGER, PLATE 6, FIG. 3

When erecting transformers it is necessary to provide a support for the pulley blocks. A common means of support is a rope sling looped around the pole immediately above the crossarm which supports the primary line wires. Different methods of placing a sling over the line crossarm may be used, and each presents some hazard to the lineman. To eliminate this hazard and to provide a support which can be quickly placed in position, the block hanger was designed. It can be placed on the line crossarm by a lineman in a low position on the pole by the use of the special tools provided.

The pulley blocks are raised by a hand line over the "V" of the hanger and are guided into place by a lineman in a low position on the pole using a switch stick and a spring head attached to a block spud. The block spud, Plate 6, Fig. 4, is a flat piece of steel which has previously been fastened to the hook of the pulley blocks.

The block hanger was made from 5/8 in. round rod of special purpose steel. Each hanger bears the stamp of the laboratory to prevent unwarranted use of substitutes.

In order to detect any flaws which might be present in the material, each hanger was tested by being fastened securely in a vice and then struck heavy blows with a hammer, throughout its entire length.

This hanger is safe to use in the erection of 25-cycle transformers up to $37\frac{1}{2}$ kv-a. capacity, provided care is taken to see that the crossarm and pole supporting it are in good sound condition. The limit of its capacity is determined by the condition of the pole and the single crossarm assembly. Tests were conducted in the laboratory using new crossarms.

In one test (Plate 7) a pine pole which was wet from exposure to rain for several days, was used. In this test, with 3000 pounds pull on the han-

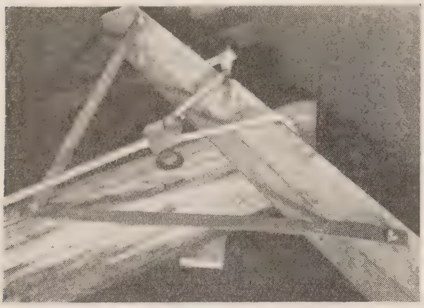


Plate 7—Test of block hanger, no load.

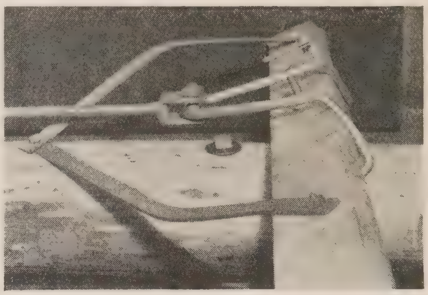


Plate 9—Test of block hanger, 4500 lb. pull.

ger (Plate 8) there was a slight depression in the crossarm wood under the hanger hooks and the crossarm had turned slightly. Evidence of this is the small gap of about 1/8 in. between the top edge of the crossarm and the pole. Increasing the pull on the hanger did not cause any substantial change until the load reached approximately 4000 pounds. At a load of 4500 pounds (Plate 9) the crossarm braces had become bent and the crossarm had turned enough to spread the hooks of the hanger.

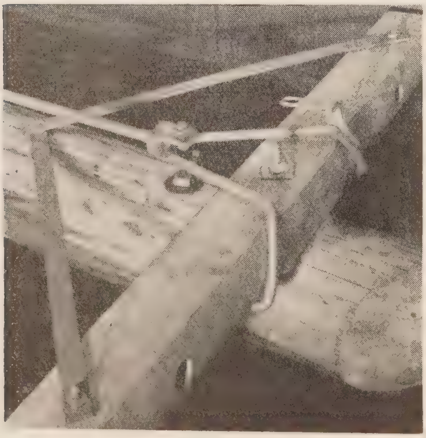


Plate 8—Test of block hanger, 3000 lb. pull.

In another test conducted with a new eastern cedar pole and new crossarm with 30 in. braces no distress was observed in the hanger or in the crossarm mounting until the load reached 4000 pounds. At 5000 pounds the crossarm braces showed signs of bending and at 5500 pounds they were definitely deformed.

The number of 3 kv-a. transformers in the rural power districts far exceeds that of all other capacities combined. In a few cases a 37½ kv-a. transformer is used. The weight of a 3 kv-a., 25-cycle transformer assembly is approximately 400 pounds, while that of a 37½ kv-a., 25-cycle, is approximately 1500 pounds.

Screw Type Wire Cutter, Plate 6, Fig. 2

To install live line clamps on old transformer installations, the present drop wires between the primary line wires and the transformers must be disconnected and removed. A wire cutter of the screw type which is operated by the standard switch stick, was designed and produced for this purpose. The cutting jaws were made of a special steel alloy. Great care was taken in the process of heat-treating these

jaws to ensure their being the required degree of hardness.

With this cutter the time taken to cut a wire is longer than with a cutter of the type having a lever and rod to actuate the movable jaw. This screw type cutter overcomes this disadvantage by better fulfilling the requirements of the rural power districts than would a lever type of cutter. Its shape makes possible the cutting of vertical drop wires, and its weight of 3¼ pounds and length of 15 inches permit it to be continually carried on a small truck. By this means the linemen always have a cutter with them should an emergency arise. The standard switch stick to which this cutter is attached when in use, insulates the lineman when cutting live conductors. It could, therefore, have been named an insulated wire cutter.

It was thought the jaws of this cutter might be damaged if an emergency cut were made of wires carrying current. Cuts were made of wires having a potential of 2300 volts and currents up to ten amperes. "A slight amount of pitting at the shearing surfaces of the cutter was observed on opening the 23 kv-a. load. However, no permanent damage was caused, and at lesser loads this effect was not noticed."

Cutout Grounding Clamp and Cutout Grounding Plug, Plate 6, Figs. 6 and 7

There are a number of fuse switches in service which are mounted on the crossarms supporting primary line wires. These serve as a means of disconnecting from the line the transformer mounted about five feet beneath them. It is expected that many of these fuse switches will remain on the line crossarms for some years. To protect linemen against leakage through damaged fuse switches, when they are doing work such as changing voltage taps, these primary connections to the transformers must be grounded.

The high voltage drop wires to the transformers are insulated, so there was need for a grounding device which could be attached to the dead contact of the fuse switch after the fuse cartridge had been removed. This presented somewhat of a problem, due to the varied types and shapes of fuse switches in use, Plate 10. The cutout grounding clamp was designed to fit the bottom contact of all open type switches now in service in the rural power districts. The cutout grounding plug serves the same purpose for all enclosed bottom pull cutouts. There is a small number of enclosed door type fuse switches mounted on the line crossarms, and it was thought that the expense of a clamp for grounding these would not be warranted. These will have to be removed from the line crossarms and erected on the transformer crossarms and live line clamps installed, so that the transformer drop wires can be disconnected.

Grounding Connection Plate, Plate 2, Fig. 5

When the changes were being made in the wiring standards of a transformer pole, it became apparent that a terminal should be provided on the pole to serve as a junction point for all grounding wires. Fatalities have occurred on account of undiscovered breaks in the grounding connections. The grounding connection plate was recently developed, and it will be used on all future transformer installations.

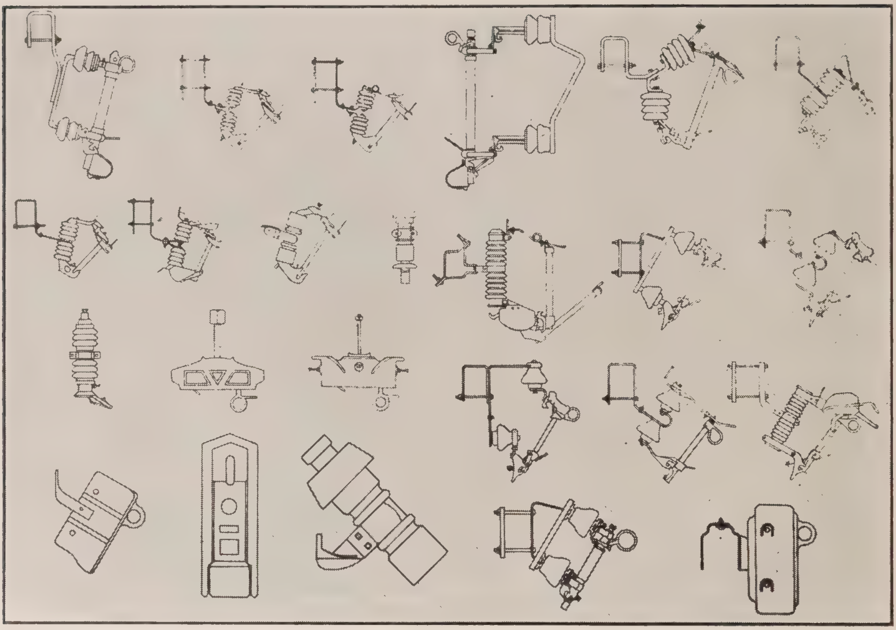


Plate 10—Types of fuse switches in use in Rural Power Districts.

Instructions are that care must be taken to see that all grounding wires are free of joints, and that when necessary to disconnect any of these grounding wires, it be done at the grounding connection plate. The disconnecting of the grounding wire at the ground rod for testing grounds is now eliminated, as this can be done at the grounding connection plate. The men are warned, of course, to wear rubber gloves while doing this work, since the breaking of a connection carrying fault current, which is not apparent, might have a serious effect.

Universal Pole Head, Plate 11, Fig. 2

The universal pole head, which is made of bronze, serves as a means of fastening different small tools to the standard switch stick.

Blade Tie Wire Remover, Plate 11, Fig. 1

This tool is made to fit the pole head. It is used to unwind and remove both bare and insulated tie wires from line conductors supported by small insulators. The tie wires on small insulators are fastened so tightly in the insulator grooves that it is difficult to cut them with a wire cutter. To remove a tie wire, one end of it is pried away from the line and it is then unwound and removed.

The blade is of hardened steel and is cast into the bronze body.

Skinning Knife, Plate 11, Fig. 3

The great majority of the primary lines in rural power districts are not covered with insulation. For the few that are insulated a skinning knife has been designed. This knife is not in regular

Plate 11—Live line tools.
Fig. 1—Tie wire remover.
Fig. 2—Universal pole head.
Fig. 3—Skinning knife.
Fig. 4—Hand line block.
Fig. 5—Socket wrench.

use, but a number of them are being given a field test to learn if they will be satisfactory. The bronze body, into which the hook-shaped steel blade is rivetted, is made to fit the universal pole head.

HAND LINE BLOCK, PLATE 11, FIG. 4

The hand line block was designed for hoisting crossarms and light weight material or tools to the lineman on the pole. This relieves the lineman from lifting these articles himself.

It consists essentially of a 1/8 in. steel plate approximately 4 in. by 4 in., on which is mounted a 2-inch sheave, grooved for ½-inch diameter rope. Two parallel semi-circular hooks extend from the top of the plate. A hardened piece of steel at the end of each hook can be set for crossarm mounting or may be reversed and secured by two set screws, when it is desired to place the hand line block over the roof of a pole. An extension of the sheave guard forms a spud to fit into the spring head. The lineman, from a low position on the pole, places the hand line block on the pole top or over the top crossarm. When placed on the pole top the hooks straddle the roof ridge and the points sink into the wood pole. To ensure that this tool will be used for its intended purpose it has been labelled: "Maximum Capacity 100 Lbs.". When tested it supported a load of approximately four times this amount before showing any sign of distress.

The Committee on Operating Instructions and Safety Rules have completely rewritten "Rules and Regulations Regarding the Operation of Lines and Equipment of Rural Power Districts". The success in the use of these tools is due in large measure to this complete set of rules.

Only men with sufficient length of service and experience to qualify as Class "A" linemen are selected to use this equipment. They are then schooled in the rules and instructed in the use of the tools on a dummy line. For a certain period the men practice on a dead line under the direction of their superintendent. They are then examined in their knowledge of the rules and their proficiency in the work and, if passed, are provided with special Rule Books and given permission to work with the tools on poles carrying live line conductors.

The results obtained, working under the present rules and with the new tools, have been satisfactory in regard to safety, and also in economy of oper-

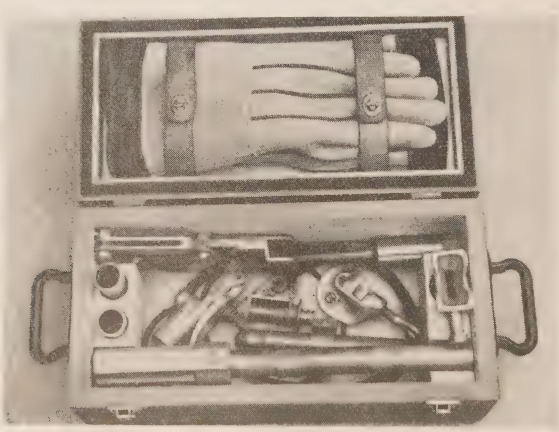
ation. It should be borne in mind, however, that this work is carried out on those pole lines of the Ontario Hydro Commission which are not loaded with wires and attachments similar to the lines in some municipalities. On such lines, therefore, safe clearance is available, and the full use of the operating sticks is not hampered.

Men are permitted to work with these tools on lines of voltages up to 4600-8000 volts. With the continuance of satisfactory results, it may be possible to extend this to 6900-12000 volt lines. Also, it may be expected that progress will be made by extending the work on live lines to include operations which must now be done with the lines dead. Advancement may seem to be slow since it is first necessary to procure the proper tools and subject them to careful tests at the laboratory and in the field before amending the operating rules and extending the training of the men to permit them to be put into general use.

To any municipal Hydro system which may later contemplate the establishment of the use of tools such as these, we would sound a note of warning. Do not permit the use of such tools and equipment unless you have the means for selecting the proper linemen and giving to them complete instructions and training. Any course short of this will not have a record free of accidents.

The Committee gratefully acknowledges the assistance given by men in the different departments of the Commission's service. Their advice and assistance made possible the designing, production and testing of a complete set of fittings and their attendant tools. To the Production and Service Department of the Commission we are indebted for the building of the models, and in some cases the complete manufacture of certain special articles.

The members of the Live Line Clamp Committee are: Messrs. C. W. Moat, A. W. Murdock, K. W. MacDermott, E. W. Smithson, J. H. Caster, D. I. Nattress, S. K. Cheney and E. R. Lawler.



Tools in tool box.

a

b

Above:—

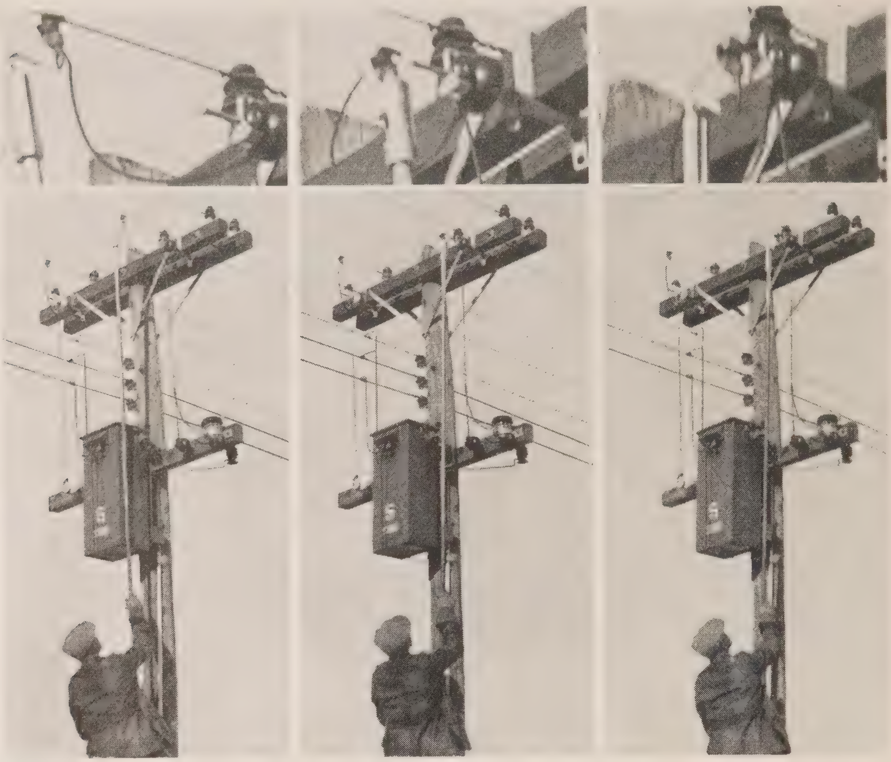
Preparing for the installation of live line clamps.

a—Screw type wire cutter being used to cut the drop wire.

b—With blade tie wire remover the remainder of the drop wire is removed.

At right:—

The pulley blocks are raised into position by a hand line over the V of the hanger.



a *b* *c*

Above:—

Disconnecting a transformer from a live line.

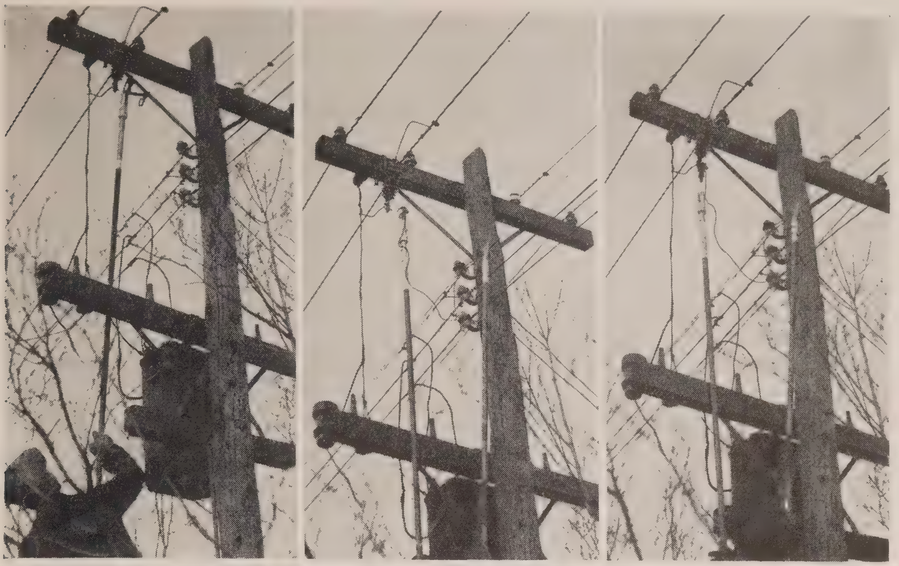
a—Spring head in open position about to engage the clamp.

b—Clamp in the head being placed on the clamp rest.

c—Clamp secure on the rest and spring head disengaged.

At left:—

Where horizontal insulators are already in place drop wire supports only are used.



a *b* *c*

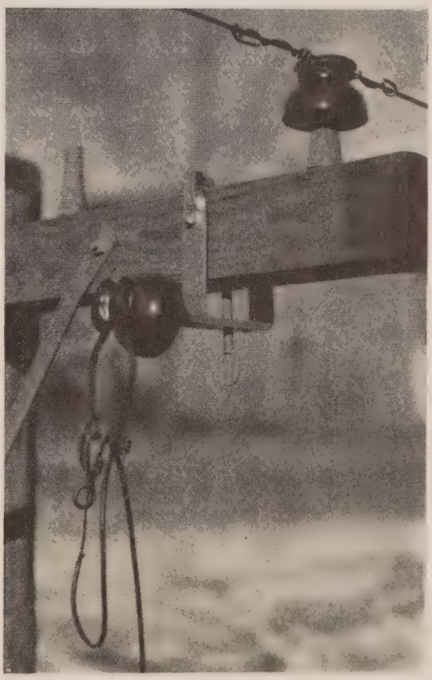
Above:—

With cutout grounding clamp protection ground is applied.

a—Removing the fuse cartridge.

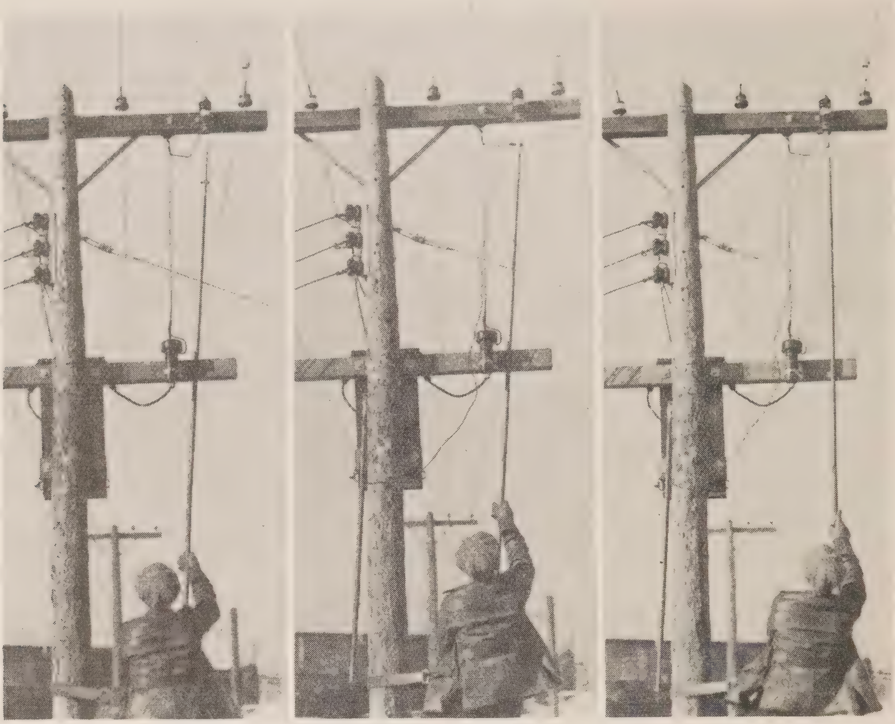
b—Grounding wire has been clamped to grounded line neutral. Proceeding to attach cutout grounding clamp to dead terminal of switch.

c—Grounding completed, tool being removed.

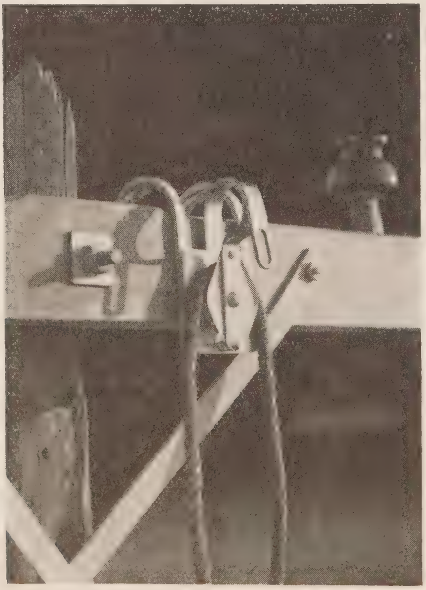


At right:—

For installation of clamps on live lines crossarm brackets are used.



a *b* *c*



Above:—

Cutout grounding plug protects the lineman.

a—Removing the fuse cartridge.

b—Putting grounding plug into bottom pull cutout.

c—Grounding completed tools being removed.

At left:—

Hand line block in position on the crossarm.

Municipal Loads, January, 1942

NIAGARA SYSTEM

25 and 66-2/3 Cycle

	H.P.	Population
Hamilton	160,556	163,768
St. Catharines	27,641	30,406
Trafalgar Twp.	535	V.A.

66-2/3 Cycle

	H.P.	Population
Bronte	191	P.V.
Oakville	1,236	3,869

GEORGIAN BAY SYSTEM

60-Cycle

	H.P.	Population
Alliston	356	1,437
Arthur	162	1,038
Barrie	3,985	9,521
Beaverton	242	915
Beeton	136	569
Bradford	178	1,004
Brechin	43	P.V.
Cannington	187	705
Chatsworth	88	321
Chesley	516	1,743
Coldwater	133	606
Collingwood	2,359	5,342
Cookstown	84	P.V.
Creemore	145	638
Dundalk	231	703
Durham	415	1,854
Elmvale	213	P.V.
Elmwood	71	P.V.
Flesherton	65	457
Grand Valley	116	629
Gravenhurst	1,230	2,193
Hanover	1,334	3,235
Holstein	19	P.V.
Huntsville	1,255	2,764
Kincardine	704	2,470
Kirkfield	28	P.V.
Lucknow	340	1,015
Markdale	177	795
Meaford	756	2,759
Midland	3,739	6,600
Mildmay	146	756
Mount Forest	519	1,909
Neustadt	44	468
Orangeville	721	2,608
Owen Sound	5,043	13,659
Paisley	145	727
Penetanguishene	989	4,076
Port Elgin	499	1,374
Port McNicoll	100	940
Port Perry	239	1,145
Priceville	10	P.V.
Ripley	98	439
Rosseau	36	310
Shelburne	229	1,018
Southampton	504	1,515
Stayner	258	1,013
Sunderland	81	P.V.
Tara	109	483
Teeswater	160	840
Thornton	22	P.V.
Tottenham	99	532
Uxbridge	371	1,535
Victoria Harbour	81	979
Walkerton	904	2,523
Waubaushene	87	P.V.
Wiarton	341	1,760
Windermere	26	118
Wingham	597	2,149
Woodville	94	425

EASTERN ONTARIO SYSTEM

60-Cycle

	H.P.	Population
Alexandria	234	1,951
Apple Hill	43	P.V.
Arnprior	1,245	3,898
Athens	128	700
Bath	34	315
Belleville	6,797	14,678
Bloomfield	107	629
Bowmanville	2,575	3,800
Brighton	345	1,556
Brockville	4,477	10,463
Cardinal	256	1,576
Carleton Place	1,746	4,275
Chesterville	308	1,061
Cobden	97	639
Cobourg	2,212	5,268
Colborne	232	942
Deseronto	167	1,300
Finch	95	347
Hastings	107	772
Havelock	149	1,156
Iroquois	237	1,068
Kemptville	375	1,223
Kingston	13,511	23,989
Lakefield	321	1,413
Lanark	95	734
Lancaster	55	563
Lindsay	3,763	7,203
Madoc	204	1,054
Marmora	140	997
Martintown	35	P.V.
Maxville	111	760
Millbrook	93	728
Morrisburg	238	1,555
Napanee	1,265	3,234
Newcastle	223	698
Norwood	169	703
Omemee	232	547
Orono	101	P.V.
Oshawa	19,860	24,938
Ottawa	35,252	145,183
Perth	1,743	4,182
Peterborough	12,413	24,017
Picton	1,059	3,582
Port Hope	2,343	4,812
Prescott	1,149	3,120
Richmond	74	409
Russell	69	P.V.
Smiths Falls	2,577	7,672
Stirling	265	981
Trenton	4,636	7,222
Tweed	207	1,246
Warkworth	81	P.V.
Wellington	157	934
Westport	93	710
Whitby	1,459	3,863
Williamsburg	106	P.V.
Winchester	311	1,059

THUNDER BAY SYSTEM

60-Cycle

	H.P.	Population
Fort William	16,827	30,317
Nipigon Twp.	197	V.A.
Port Arthur	45,721	21,284

NORTHERN ONTARIO PROPERTIES

Nipissing District

60-Cycle

	H.P.	Population
North Bay	4,378	15,797

Patricia District

60-Cycle

Sioux Lookout	338	1,933

Sudbury District

60-Cycle

Capreol	247	1,700
Sudbury	9,086	32,731

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The BULLETIN

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The Hydro-Electric Power Commission of Ontario

Volume XXIX MARCH, 1942 Number 3

Double circuit, 110 kv. wood pole line serving a Northern Ontario mining area.

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Municipal Loads, February, 1942

NIAGARA SYSTEM
25-Cycle

	H.P.	Population
Acton	1,457	1,903
Agincourt	171	P.V.
Ailsa Craig	118	487
Alvinston	102	649
Amherstburg	965	2,704
Ancaster Twp.	351	V.A.
Arkona	57	403
Aurora	1,188	2,821
Aylmer	798	1,985
Ayr	222	760
Baden	496	P.V.
Beachville	656	P.V.
Beamsville	359	1,227
Belle River	166	836
Blenheim	531	1,873
Blyth	116	662
Bolton	185	629
Bothwell	138	683
Brampton	2,702	5,702
Brantford	20,208	30,947
Brantford Twp.	1,040	V.A.
Bridgeport	151	P.V.
Brigden	83	P.V.
Brussels	136	784
Burford	199	P.V.
Burgessville	40	P.V.
Caledonia	402	1,430
Campbellville	42	P.V.
Cayuga	140	700
Chatham	6,840	17,148
Chippawa	335	1,228
Clifford	96	491
Clinton	625	1,879
Comber	126	P.V.
Cottam	86	P.V.
Courtright	49	355
Dashwood	78	P.V.
Delaware	67	P.V.
Delhi	668	2,430
Dorchester	125	P.V.
Drayton	125	528
Dresden	387	1,525
Drumbo	104	P.V.
Dublin	41	P.V.
Dundas	2,915	5,001
Dunnville	1,404	3,916
Dutton	252	830
Elmira	857	2,069
Elora	422	1,185
Embro	114	420
Erieau	73	281
Erie Beach	10	21
Essex	550	1,886
Etobicoke Twp.	6,975	V.A.
Exeter	572	1,654
Fergus	1,271	2,759
Fonthill	175	860
Forest	480	1,562
Forest Hill	7,318	12,172
Galt	10,892	14,584
Georgetown	1,725	2,452
Glencoe	206	763
Goderich	1,340	4.674
Granton	57	P.V.
Guelph	11,526	22,500
Hagersville	476	1,347
Harriston	342	1,292
Harrow	468	1,092
Hensall	176	686
Hespeler	2,947	2,938
Highgate	88	322
Humberstone	572	2,831
Ingersoll	2,993	5,186
Jarvis	208	513
Kingsville	688	2,453
Kitchener	26,527	33,281
Lambeth	130	P.V.
LaSalle	208	907
Leamington	1,854	6,048
Listowel	1,331	2,984
London	40,478	75,176
London Twp.	593	V.A.
Long Branch	1,116	4,258
Lucan	154	643
Lynden	107	P.V.
Markham	289	1,175
Merlin	105	P.V.
Merritton	7,856	2,916
Milton	1,011	1,915
Milverton	320	994
Mimico	2,582	7,713
Mitchell	655	1,670
Moorefield	40	P.V.
Mount Brydges	100	P.V.
Newbury	29	288
New Hamburg	602	1,441
Newmarket	1,626	3,800
New Toronto	11,298	7,514
Niagara Falls	10,480	18,770
Niagara-on-the-Lake	699	1,764
Norwich	366	1,301
Oil Springs	194	541
Otterville	106	P.V.
Palmerston	559	1,400
Paris	2,016	4,604
Parkhill	199	1,029
Petrolia	1,215	2,768
Plattsville	116	P.V.
Point Edward	1,709	1,199
Port Colborne	2,031	6,772
Port Credit	793	1,934
Port Dalhousie	824	1,599
Port Dover	401	1,790
Port Rowan	105	700
Port Stanley	284	824
Preston	4,113	6,337
Princeton	106	P.V.
Queenston	109	P.V
Richmond Hill	414	1,295
Ridgetown	590	1,986
Riverside	1,105	5,235
Rockwood	106	P.V.
Rodney	162	758
St. Clair Beach	70	138
St. George	142	P.V.
St. Jacobs	302	P.V.
St. Marys	1,432	4,009
St. Thomas	8,162	16,461
Sarnia	10,741	17,979
Scarborough Twp.	4,438	V.A.
Seaforth	623	1,782
Simcoe	2,437	6,340
Smithville	147	P.V.
Springfield	68	382
Stamford Twp.	2,282	8,275
Stouffville	249	1,198
Stratford	6,998	17,163
Strathroy	1,249	2,834
Streetsville	196	701
Sutton	166	949
Swansea	3,217	6,606
Tavistock	608	1,080
Tecumseh	333	2,331
Thamesford	188	P.V.
Thamesville	225	816
Thedford	81	598
Thorndale	63	P.V.
Thorold	2,530	5,080
Tilbury	1,134	1,923
Tillsonburg	1,374	4,602
Toronto	372,249	648,098
Toronto Twp.	2,344	V.A.
Wallaceburg	3,181	4,802
Wardsville	37	221
Waterdown	208	867
Waterford	525	1,294
Waterloo	5,241	8,690
Watford	339	1,023
Welland	12,102	11,568
Wellesley	108	P.V.
West Lorne	251	768
Weston	4,404	5,784
Wheatley	179	761
Windsor	50,153	103,571
Woodbridge	651	946
Woodstock	8,053	11,584
Wyoming	78	538
York Twp.	19,594	77,175
York E. Twp.	8,165	38,316
York N. Twp.	8,411	V.A
Zurich	104	P.V

／THE
BULLETIN

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Problems Resulting From the War

By M. J. McHenry, Priorities Officer, H.E.P.C. of Ontario

WHEN the paper which I have been asked to sponsor this morning was originally discussed, I believe that the intention of the Committee was that this paper should deal to a very large extent with the procurement of the necessary equipment and material which the utilities of Ontario require, and the method by which that material might be obtained under the very difficult wartime conditions.

However, a consideration of the subject which was chosen, "Problems Resulting from the War", would indicate a very comprehensive field, and I suggested to the Committee that this paper should be expanded and that it should be dealt with from more angles than the one which I have previously mentioned.

As a result, I am happy to say that this paper will be in three parts, each taken by a different man. Three phases of the problems that may arise, or have arisen as a result of the impact of the war, will be dealt with.

———

Addresses to the Association of Municipal Electrical Utilities at Toronto, February 11th, 1942.

Possibly the three main fields for consideration are the planning of system operation, and apportioning of load between essential and non-essential uses, and the procurement of those materials for necessary expansion operations and maintenance.

The field of operation will be covered by Mr. H. J. Muehleman, Chief Operating Engineer for the Commission. The opportioning of load, and the uses to which electricity can be and cannot be put, will be dealt with by Mr. J. J. Jeffery, of the Municipal Department.

Let me now endeavour to present some of the conditions which obtain in the procurement of necessary materials for our continued operation.

Nearly everyone is aware of the expansion of industry to produce equipment for our armed forces, munitions of all kinds and mechanical equipment required by modern warfare.

Such expansion must have two principal effects on utility systems. One relates to the availability of material, and the other, to the supply of electrical energy to turn the wheels of industry.

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MARCH, 1942

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The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

The consumption of material such as steel, copper, rubber, nickel, tin and other metals, has been so greatly increased by the demands of war as to demand almost the total productive capacity of the country for the fulfilment of war and essential services only. This leaves little, if any, in many cases, for ordinary civilian use.

Correspondingly, the consumption of power has been increased at the same relatively high rate, finally reaching a point where little, or none is available for increased civilian use.

The entrance of Japan into the conflict, and the consequent disorganization of the flow of raw materials from the Pacific and East Indian areas, has made the shortage of certain materials such as tin, rubber and manila hemp, extremely acute, and has also necessitated the allotment of such materials exclusively for essential war purposes. Not only any war expansion program, but also the maintenance of any electrical utility system, requires the use of these materials in reasonably large quantities. The new power developments, transmission lines, apparatus for the generation, transmission and distribution of electrical energy, all of these require the use of steel, copper, zinc, tin, rubber, timber, in quantity.

It is paramount that the requirements for war purposes shall be filled without question, and that essential services shall be met. Failure to make this provision would undoubtedly result in disastrous defeat.

To provide for these conditions, it has been necessary for the Government to establish such control as will ration all of these materials in their proper proportion to the various services required. Not only is the control established for the purpose of allotting materials, but also for the purpose of curtailing non-essential expansion to the detriment of the war work. In both Great Britain and the United States, it has been necessary to establish similar rationing systems.

In the United States, this soon became apparent following the Lease-Lend agreement with Great Britain and other countries. The system originally followed in the United States was a system of formal priority ratings, whereby ratings in various classifications were granted for the procurement

of material and equipment according to the degree of essentiality of the complete project.

For example, the army, the navy, the air force and direct munitions supplied, received very high ratings, and the ratings were proportioned down in accordance with the degree of essentiality established by the Government.

In this system, the higher ratings naturally were assigned to material and equipment for the armed forces, and the Government projects for definite war services. In the early stages such a system worked reasonably well, but as the shortage of materials became more and more acute, and as the expansion program more and more developed, this system bogged down, and is now being replaced by a system of allotment of materials on monthly schedules.

In Canada a formal priority system with published ratings was not established, and the tendency has been from the start, to use a system of allotment of materials on monthly schedules, rather than by formal priority rating.

The Canadian Government established a Wartime Industries Control Board, whose membership is composed of the various Controllers of supplies and of materials, and who have the power to ration all material, equipment and services, in order that the maximum war effort may be attained. As a result, we are now operating under the rulings of this Board, and under the direction of the Controllers of Steel, Non-ferrous Metals, Power, Construction, Supplies etc.

The present situation is extremely fluid. I had prepared a paper which was ready something more than ten days ago, to place before you this morning, but have had to discard most of that paper and prepare, or attempt to prepare another, because of the changes which have taken place during the last week, and the rulings of the various Controllers which have come out. Changes in the supply of various types of materials are coming so rapidly that it is very difficult indeed, to keep up with the requirements at the present time.

As an example, up to the present time, it has not been necessary for the Hydro utility system in Ontario, nor for The Hydro-Electric Power Commission to apply for and obtain a permit from the Controller of Construction for the erection of buildings, lines, or other projects.

I received this morning from Ottawa the complete order of the Controller of Construction, and it is now necessary on all jobs which we undertake, and which you will undertake, amounting to over $5,000.00, that you must apply for and obtain from the Controller of Construction at Ottawa, a permit to proceed with such project. If you have a project under construction and not completed, it is also necessary that you immediately apply to the Controller of Construction for a permit to proceed with that project, if the total amount of the project is over $5,000.00.

Apparently this applies to any building, any construction of permanent structure, any operation that we may have, including the repairs, maintenance and rehabilitation of our stations.

I am not yet sure whether that permit will bear any degree of essentiality, any priority rating, as it were, but the understanding, up to the present time, is that it does not do so. Therefore,

following the attaining of such permit, we still have the problem of obtaining any material which we require for the project, and that material will have to be obtained by a reference to the various Controllers,—the Steel Controller, the Metal Controller, the Controller of Supplies, and others.

Possibly a clearer picture of this may be obtained by considering the various classifications of material which are necessary. In doing so, I would like to start with those materials which are now very short. I refer to the materials which I have mentioned previously, for the supply of which in the raw form we are very largely dependent on the East Indies—tin, rubber, manila hemp. We will no longer be able to obtain manila hemp. What manila rope there is in the country is held almost exclusively for the navy, mercantile marine, and the fishing industry, where it is required to withstand salt water action. I believe a wartime rope of other fibre is being produced, and this rope has about eighty per cent of the strength of manila hemp rope, and will be obtainable for the use of utilities.

Tin is also very short. The Controlling Officers are trying to stretch the supplies in Canada as far as possible, and naturally, to retain the maximum or necessary quantity of that metal for essential war purposes. As a result, the tin content of solder has already been reduced, and may be reduced still farther. It is no longer possible to obtain any solder of a greater per cent of tin content than thirty-eight, and that is only for wiping solder. Ordinary solder is about fifteen per cent tin content.

Bearing metals are affected, and everybody is being asked to use bearing metals without tin content on all types of equipment. That is something which we have to consider. Other uses of tin are being restricted accordingly.

Rubber is in a similar situation. Probably ninety per cent of our raw rubber comes from the East Indies, and it is not now possible to obtain it there. Whether artificial rubber will be available and when it will be available, is very questionable at the present time. You have already noticed in the press that rubber products are being drastically limited, and as far as the utilities are concerned, I can say that all utility trucks and equipment, owned and operated by utility systems, will have tires made available, provided they are owned by, and operated exclusively for the operation of the utility. Cars which are not owned, and which are not operated one hundred per cent for the use of the utility system, will receive no other consideration than the ordinary passenger car. In other words, new tires for such cars are banned.

Consideration is being given at the present time in some forms of rubber-covered wire, to replace the rubber insulation with a triple braid impregnated insulation. This may be forthcoming shortly.

The Controller of Supplies is asking that wherever possible, wire or conductors using some other form of insulation or, if possible bare conductors, be used in preference to anything having rubber insulation, and it is going to become very much more difficult to obtain rubber insulated conductors than it has been in the past. Not only is the supply of conductors limited in so far as use of rubber as insulation is concerned, but the requirements of copper for war pur-

poses are very very high indeed, with the result that the productive capacity of copper refining plants is limited, for uses other than direct war purposes—very much limited indeed. Therefore, the Metals Controller is asking that we do everything possible to conserve the use of copper conductors.

I believe that all utility systems have received recently a letter from the Metals Controller, including a form on which to report their stocks of metals—copper, tin, aluminum and all non-ferrous metals. You will note on that report form, if you have received it, that you report monthly to the Metals Controller on one sheet, total stocks of these materials at the beginning of the month, receipts, the amount used, and the balance at the end of the month; and on the reverse of the sheet, it is necessary to make a statement with regard to the amount and uses of conductors of various sizes, both copper and aluminum, rubber-insulated and lead-covered, and various other types of conductor which you may have in stock.

In addition, it is also necessary for the utility to report any copper or tin alloys which they have in stock.

In the letter which was forwarded with this stock reporting form, Clause 2 asks you not to make any extensions or additions to your system without first obtaining the approval of the Metals Controller as to the supply of equipment.

When that letter reached me, I felt that not only The Hydro-Electric Power Commission, but also all of the utility systems of Ontario were immediately withheld from carrying out any operation whatsoever, involving non-ferrous metals. In communication with the department of the Metals Controller at Ottawa. I was advised that this was not exactly the intent of this Clause No. 2.

The intent was that, for the moment, where it became necessary for the utility system to purchase conductors and non-ferrous metals, to proceed with any work, that they should first obtain the approval of the Metals Controller for such purchase.

Now, if you will read that letter carefully, you will note that it is not an order from the Metals Controller, but a request, and the department of the Metals Controller has suggested that your organization should undertake to advise him as to the best method for control of this equipment.

There are many factors involved. Naturally, the Metals Controller is desirous of limiting to the least possible amount, the new material required or specified by the utility system. At the same time, he is anxious that any essential service shall be taken care of. There are many problems involved in bringing out a system of control which will properly take care of this particular situation, in so far as the electrical industry is concerned.

For example, there is the problem of the present material in hand. Is the present material on hand in the storehouses of the systems of Ontario sufficient to carry them for some considerable time on their ordinary operations? And, by some system of pooling or arrangement among the utilities, can that stock be spread so as to carry for some time the municipalities to advantage in the present situation?

At the same time, I think that it will be necessary for some suggestions to be

given to the Metals Controller and his department, as to what should be classified as an essential work which should be gone ahead with, and what should be classified as non-essential. Consequently, at the request of the Metals Controller, I present to you that you should give some thought to these problems. The Controller will welcome any suggestions or recommendations which your organization or any utility system can give with regard to how this can be effected to the best advantage of the war and the utility system.

Now, there are other Controllers at Ottawa. Under the Controller of Supplies comes quite a long list of materials—rubber, rope, and a large number of other materials, but rubber and rope are possibly the two principal ones with which we are concerned.

Under the Timber Controller comes the supply of all lumber and timber; under the Steel Controller the supply of all steel. The steel situation at the present time is very acute, particularly so with respect to steel plates. All steel plate today is being rolled on monthly schedules, set up for the steel producers by the Steel Controller's department at Ottawa. In order to obtain steel plate, it is necessary for the manufacturer or the utility, or whoever the purchaser may be, to provide the Steel Controller, on the 15th of each month, with his requirements for steel plate or steel products, for the following month's rolling.

Frankly, at the moment, not all of them are getting on the steel schedule. The reason for this being that the increase in the requirements of steel has been so great that it is not possible to allow all requirements each month. It must be appreciated that a tremendous quantity of steel plate is being required for the shipbuilding industry. You have already had much information as to the production of Canada in vessels for the navy and for the Merchant Marine, and the requirements of steel for these vessels is very great. Over and above that are all the normal requirements of the munitions industry of one type or another.

I would like to say a word with reference to the procurement of equipment and material from the United States. This has presented considerable difficulties to many of the utilities of the Province, and The Hydro-Electric Power Commission of Ontario. Up to the present, the only method by which material can be obtained from the United States, when ordering directly or ordering through a Canadian agency, was by the use of what is known as the PD-1 form. This is a complicated and detailed form requiring many questions to be answered. Furthermore, if the questions are not all answered satisfactorily, it won't get by Ottawa, let alone go to Washington.

This form is made out in individual cases by the utility, where the utility is ordering directly in the United States, and the material or equipment is being shipped directly to the utility, or where it is ordered through an agency, who does not in any sense, fabricate, add to, or improve on the equipment after its arrival in Canada. In such cases, the onus is on the utility to make out the form of application.

Incidentally, it takes anywhere from three to six weeks for the application to go through. The form goes to Ottawa, is approved there, and thence

to Washington, and finally notification is received of the certificate and rating applying thereto.

This situation is easing to some extent at the present time. Recently, the United States Government allowed the extension of what is known as their P-100 order to Canadian manufacturers. We have been, on behalf of the Hydro, endeavouring to obtain extension of the United States P-46 order for utilities in the United States to apply to the utility systems of Canada, but up to the present time, this has been refused by the United States Government. The P-46 order in the United States permits the utility systems of the States an A-10 rating for all material and equipment for repairs and maintenance.

It is not applicable in Canada, but recent word from Ottawa is to the effect that a representative of the War Production Board of the United States Government is to be located in Ottawa, and that it is expected that in the future, all applications for United States priorities will be handled at Ottawa. I believe that this will very much simplify and shorten the process and help us materially, and it may ultimately result in the extension of the P-46 order to the utility systems of Canada.

The PD-1 which I mentioned previously, has now been changed to a PD-1A form, which is considerably simplified, and is now also extensible. By extensible, I mean that it is now possible of being extended to your supplier, so he may extend down the line to his supplier of raw materials.

What do all these difficulties mean to us in the way of procurement of our necessary materials? I think they call for a very concentrated effort on the part of all those engineers who are associated with utility systems. The problems which we have to face now are entirely different from the problems which we have had to face during the times of peace. The process of purchasing and procuring material and equipment in peace times was comparatively simple, but that process has gone by the board, and it is now necessary to go through very many additional operations in order to procure any of the equipment and material which we need.

Today, the situation has become so acute that it is necessary to establish a very sound and essential use for the material required. In many cases today, to purchase material it is absolutely necessary that a signed statement be included on the purchase order to the effect that the material ordered does not entail a greater stock in conjunction with present holdings than thirty days' supply for the purchaser's needs.

In other words, the Government's Control Officers are trying to prevent the accumulation of excess supplies of material and equipment and to ration all of that material and equipment in such a way that no excess stocks or hoarding obtains. Further, that material of any kind is obtained only where the use of that material is essential.

These conditions present interesting problems for the utility engineer. One is the question of substitution. For example, there is no more manila rope. There is very little tin. There is very limited supply of rubber.

Consequently, utility engineers must exercise every bit of ingenuity which

they possess in the replacement, where possible, of these scarce materials with other materials which are more easily obtainable.

For example, bearing metals are now procurable without any tin content, and apparently these are giving very satisfactory service.

There is another angle to this question of ingenuity, having a bearing on the operation of our systems. The Government has indicated and is definitely expecting that the utility systems of Canada will refrain from carrying out any expansion that is not necessary. I refer to operations such as improvement of voltage regulation to give the maximum of service, to the maintenance of high factors of safety, and to the provision of spare feeders, and spare equipment.

Where these are not essential the Government is expecting that the utilities will operate without their provision for the time being, and will make the maximum use under all conditions of the equipment which they now have in hand.

Brief mention has been made of hoarding. This is the procuring of large supplies of scarce material and holding them out of production, out of use, believing the future may hold some place in it in which they may be of use, and they may not be obtained at that time. Such action defeats the purpose of Government controls, and we are definitely asked to avoid this hoarding of material and equipment.

In fact, many of the control orders now specify—I think more will specify in the future—that it is necessary for you to attest on your purchase order that the equipment or the material being purchased, together with the stock in hand, will not constitute more than thirty days or alternately, three months' supply.

There are many other phases of this situation, but time does not permit consideration of them. In conclusion, I would recommend that you keep closely in touch with the Orders-in-Council that are issued on behalf of the several Controllers, in order that you may be reasonably well acquainted with changing requirements. Possibly the best way to do that is to follow the advertisements which are now appearing in the newspapers and also to refer to the Canada Gazette, which publishes all of these Orders as rapidly as they are issued.

* * * *

By H. J. Muehleman, Operating Engineer, H.E.P.C. of Ontario

From the point of view of the Commission's Operating Department, the problems presented by the war have been many, and in most instances tie in closely with what has already been stated here by Dr. Hogg.

Practically speaking, under present conditions, there is a market for every kilowatt-hour available to the Commission, and in fact the demand threatens to exceed the supply. Consequently, it is in the National interests to make the most efficient use of the resources available, and, therefore, problems of water supply for power generation, the utilization of power available under purchase agreements, and the limitation of losses in generation and transmission become of the greatest importance and constantly demand our closest attention.

You have already been told of the rapid increase in the demand for power which has occurred due to the wartime conditions, and a few of our problems resulting from this increase, together with other war effects therefrom, may be of interest to you.

Personnel

Expansion of industry, due to the war effort, has created a demand for skilled workers, which are also sought after by the Department of National Defence.

The demands on labour made by the greatly expanded war industry, and the demand for young men for the Army, Navy and Air Forces, greatly increase our difficulties in obtaining suitable employees to man the new stations and other equipment rapidly being installed by the Commission, and to replace normal retirement due to age.

To overcome this, we have found it necessary to raise the age limit somewhat for some of our beginner grades, to increase the hours of normal work beyond those formerly standardized, and where certain employees had reached the normal age for retirement, but are still suitable for service, these are being kept on. We have given some thought to the possibility of employing women in certain operating positions, and feel confident that with adequate training selected types could be used, but there are certain difficulties presented due to the locations of many of our stations and the lack of suitable accommodation for women employees, and, therefore, we are deferring action along this line until the need becomes more pressing. Meanwhile, we have used women on statistical work in the Head Office, where we formerly employed men, and they have proved entirely satisfactory. Incidentally, the Commission has in no instance claimed exemption from Government service for any of its employees on the basis that his services with us are indispensable.

Routine Maintenance

The greatly increased loads which of necessity could not be followed as rapidly by expanding facilities, have increased the difficulty of taking apparatus out for routine maintenance. To overcome this constantly requires careful planning, and much of the work formerly done during the daytime has to be done at night, and on Sundays and holidays.

For example, some of our transmission lines are operating at their thermal limit, leaving little margin for additional short-time overloads, such as during short circuit conditions. Such lines are liable to failure due to a bad joint which might easily be overlooked. An example of this may be cited:—

It was desired that a very essential war industry be supplied over one of our high voltage transmission lines with as much power as possible, having regard to the other load to be served and the carrying capacity of the line. When the line was loaded up to what was considered to be the safe maximum capacity, heating was observed at one of the compression type joints in the conductor, and it was feared that a similar condition might exist at other joints on this line, which is approximately fifty miles in length. Interruptions of sufficient length to adequately test the conductivity of all of the joints were out of the question, so we resorted to the simple expedient of having our patrolman test these

joints with the line alive and loaded, by using an ordinary wax candle attached to a switch stick. If a joint is running hot enough to melt the candle, we know that we have a defective joint. Fortunately, only two defective joints have been found, and to avoid long interruptions for permanent repairs, temporary repairs have been made by paralleling the defective joints with jumpers attached by means of suitable bolted clamps. It may interest you to know that the demand for power over this particular line is so great that we have taken advantage of the lower average ambient temperature in winter, by permitting heavier load currents to be carried than will be advisable under summer conditions.

The Effect of Priorities

Certain metals and materials are difficult to obtain and always require a priority rating. Some of these materials are essential for maintenance and/or replacement, but it is our duty to use them as sparingly as possible.

The maintenance of such important pieces of apparatus as hydraulic turbines, electric generators and transformers, must, of course, be kept on a high level to withstand the practically constant loading to their capacity. For this reason, little can be done to defer maintenance or to avoid using necessary materials for replacements, and in those cases, through the agency of our Priorities Officer, we have managed to keep on hand the materials necessary.

I should like to point out that the failure of a generator will usually result in the loss of the capacity of that machine for a considerable period—sometimes a matter of months—whereas the average breakdown of a transmission line can be repaired in a matter of hours. It will thus be obvious that while the maintenance of transmission lines may be deferred, that of generators and similar equipment cannot.

About 4:30 p.m. on October 7th, a cyclone wrecked in one locality the following towers on 220 Kv. transmission lines:—

2 in one line.
1 in each of the other two lines.

The location was very inaccessible, but the trouble was found shortly after midnight and permanent repairs completed four days later. Temporary service was restored on one circuit at 6:21 a.m. the next day.

Recently we lost a couple of coils and some end connections in a 45,000 kilowatt generator at Niagara Falls, and while the damage was not extensive, two weeks elapsed before the generator was restored to service.

On wood pole lines, much can be done to avoid the installation of new material as replacement. Poles are available generally, but many of our longer poles come from the west and transportation systems are already overloaded. For this reason, a very careful inspection is made of transmission lines with the idea of changing a minimum of poles, conductor or of ground wire. It is believed that, for example, ground wires or sky wire, when weakened by rust or vibration, can be removed with little sacrifice in service (such lines are generally admitted to be somewhat more vulnerable to lightning), so this is done rather than to replace it with new. Careful inspection of poles can be made and new ones installed judiciously, or at times the pole line can be lowered or a few guys added and

the line thus kept in reasonable condition over the next few years.

Another transmission line problem involving the conductor occurred recently in which age and added load due to war conditions caused an abnormal number of failures in the joints of a thirty mile double-circuit line erected nearly thirty years ago. These joints were of the twisted sleeve type, and under ordinary conditions reconstruction of this line would have been in order, but under present conditions could not be considered, chiefly because of priorities affecting aluminum and copper. The temporary expedient of jumpering the defective joints using short lengths of new conductor and modern bolted clamps was resorted to in this instance, and it is considered that these circuits will now give satisfactory service for another five or more years.

In the matter of treating poles to discourage ground line rot, our present standard method requires a great deal of galvanized sheet, for which at the present we do not feel we are warranted in asking priorities. We are studying methods of treating poles without the use of the sheet metal, and we believe that a reasonable substitute can be found as a temporary expedient.

I should mention, however, that we keep in stock minimum safe quantities of emergency replacement materials, such as spare windings for generators, spare coils for generators and transformers, spare transmission line conductor, poles, insulators, etc., for replacement in case of extensive damage, but these are kept at a minimum, and, furthermore, must be conserved and used only when their use cannot be avoided.

Painting

Generally we are now painting only where surface or other depreciation demands attention—not for appearance only. Sometimes this consists in patching where not too unsightly. This saves use of materials and economizes on labour, which is becoming increasingly scarce.

The Matter of Salvage

A few months ago, on receipt of a request from the Government that all salvageable material which could be utilized for the war effort should be collected and put to use, we immediately instituted a system-wide campaign to collect all such salvage. These salvage operations resulted in much material being disposed of; principally cast iron and steel, aluminum, copper and brass. This was carried on along with our other work, utilizing wherever possible transportation that was available. In many instances, however, these salvage operations have resulted in re-use of material, thus obviating the necessity of purchasing new. One example which comes to mind is the replacement of a broken shaft in a small hydraulic turbine for which we would have had difficulty in getting replacement and that at a considerable expenditure of time. Through our salvage operations we found a discarded shaft which, by a relatively small amount of machine work, we were able to utilize to replace the broken shaft referred to.

As has already been said, we found it difficult to keep pace with the abnormal growth in load which has required the installation of additional stations, or extensions of existing ones. Generally the power was needed before all the essential equipment could be procured and installed. Much of this

load was picked up from such stations as soon as the transmission lines to and from the station were built and the transformers necessary for transformation were installed; thus this equipment was placed in service without its complement of protecting oil breakers and relays at the new station. This resulted in some impairment in service, but obviously at a commensurate benefit due to moving forward the date of the beginning of production in the industries to be supplied.

I have tried to point out to you some of the difficulties under which we, in these times operate, but you should know also that every effort is being made to give an unimpaired service and should interruptions occur, as they will, you should remember that they have occurred in spite of all the efforts of our large and competent staff to prevent them. The supply of uninterrupted service is the sole aim of the Operating Department and its personnel.

* * * *

The address by J. J. Jeffery is not recorded. After outlining the growth of the Commission's load and the power shortage to be expected during next fall and winter, and also the plans already being enforced to curtail the addition of new services, he gave suggestions as to what might be done to reduce the use of power so that war industries will be supplied regardless of the shortage. He suggested the possible curtailment of sign lighting, window display lighting, street lighting and some domestic and commercial uses as well as non-essential power loads. He also showed how by careful use the great number of domestic uses could through small individual savings help materially in tiding over the shortage period without serious difficulty.

—*Editor*

Obituary

Thomas Jackson, North York Township

On Saturday, February 28th, 1942, Thomas Jackson, former superintendent of the Hydro-Electric Power Commission of the Township of North York passed away in his fifty-eighth year.

"Tom" was born at Lindsay, Ontario, and as a young man entered the employ of the Bell Telephone Company of Canada on line construction work. In 1910, when Toronto commenced building its Hydro distribution system. he came to the Toronto Hydro-Electric System where he remained until 1914, transferring to The Hydro-Electric Power Commission of Ontario. Here he was advanced to a foreman on wood pole line construction in 1918. The Hydro-Electric Power Commission of the Township of North York was formed in 1923, and Mr. Jackson was appointed superintendent. Here he served until July, 1941, when he was retained in an advisory capacity.

At the end of 1924, North York Hydro was serving 702 consumers and the load taken in that year was 359 h.p. In 1941 the number of consumers had grown to 6,369 and 6,363 h.p. were taken. This indicates the expansion of the system of which Mr. Jackson had charge, both as to construction and operation.

Live Line Maintenance
On Wood Pole Lines 13 to 44 kv.

By H. J. Muehleman, Operating Engineer, H.E.P.C. of Ontario

IRRESPECTIVE of the reliability of power production equipment, the service record of any large power system is dependent on its transmission and distribution lines. This accounts for the many and rapid changes which have taken place in ideas regarding the design of lines of all voltages throughout the history of the industry.

This discussion deals with transmission line maintenance and since, in general, our high voltage 110 and 220 kv. lines provide alternative sources of supply, the remarks which follow apply principally to 13 to 44 kv. wood pole lines. We are anticipating that it will ultimately be necessary to perform a considerable amount of live line maintenance on our 110 and 220 kv. lines and we, of course, expect to be prepared to do this when and as it becomes necessary.

Fig. I. Double circuit construction.

Originally the engineers of the Commission believed that an alternative source of power should be provided for every important customer and accordingly many double circuit lines were erected. You are all familiar with the conventional form of these lines, namely, a circuit on either side of the pole top, supported on two cross-arms, and a sky wire mounted on the peak of the pole. Fig. I.

Such lines have a fair performance record with respect to lightning outages but they have given an abnormal amount of trouble with long service interruptions during sleet storms, high winds, etc.

The majority of trip-outs due to lightning are caused by flashovers, which in most cases do no permanent damage, and especially if the circuit is equipped with reclosing oil breakers or repeater fuses, these momentary outages are of little consequence. It was felt, therefore, that if a line could be erected that would withstand most of the abuse to which it might be subjected from wind storms, sleet, etc. we could afford to put up with a number of minor interruptions, if even one

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Presented to the Association of Municipal Electrical Utilities at Toronto, February 11, 1942.

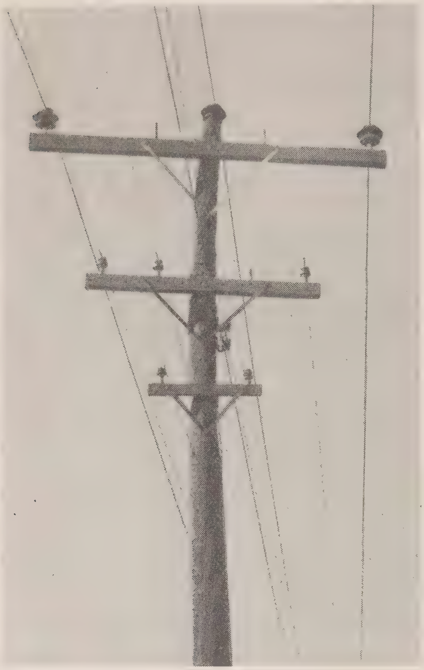

Fig. II. Single circuit construction.

long one could be avoided. This has led to the development of single circuit lines of a much more substantial type with a better configuration and more generous conductor spacing than could possibly be obtained economically on double circuit lines. Fig. II.

On a single circuit line one cross-arm supports a conductor at either end and the pole top supports the other conductor. Such a line has a phase separation of about 50 per cent greater than the customary double circuit construction and because it supports fewer conductors at a lower elevation is subject to much less lateral stress due to transverse winds. No ground wire is used, which accounts for the somewhat greater vulnerability of the line to lightning.

From the time that the use of electricity first became a commercial possibility there has been a progressively increasing demand for better service and this matter has a new emphasis and a new significance now, in the present national emergency. This has resulted in an extensive study of ways and means of shortening or entirely eliminating interruptions for work on lines and to the improvement of live line tools.

The commercial live line tools available were, in general, found to be the development of enterprising utilities for use under their own particular circumstances and not entirely suited to our requirements. Two sections of the Operating Department developed some live line tools suitable for their respective needs which was followed up by the formation of a committee whose duty it was to develop tools for general application. The results of the work of this committee are shown in Fig. III.

To manufacture a complete set of these tools costs approximately $600. We had hoped to be able to reduce this to something of the order of $500; however, the insulated parts are constructed principally of sitka spruce of the highest grade obtainable and since this material is in demand for National Defence work, it is unlikely that we will be able to reduce the cost of live line tools appreciably during the present emergency.

All such equipment undergoes very rigid electrical and mechanical tests before it is issued for use and since the effects of wear and tear in the field have a tendency to make it unsafe, it must also undergo periodic test. The present practice is to inspect and test all tools once a year. However, this

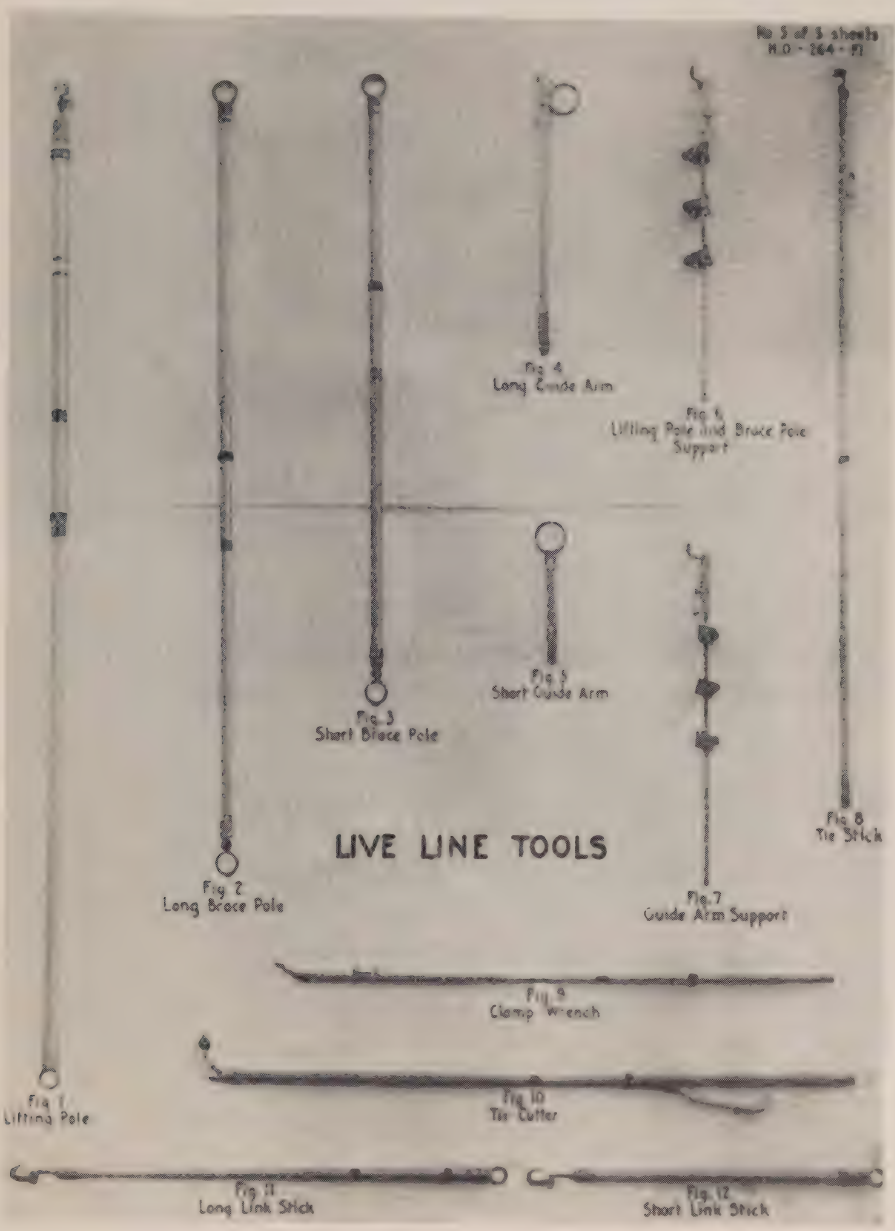

Fig. III. Live line tools.

schedule may be subject to modification depending on the facts disclosed by a number of inspections.

A mechanical test in which a lifting pole is supporting a load of about 200 lb. is illustrated by Fig. IV. In addition to proving the tools to be sound mechanically they are tested electric-

ally with voltages ranging from 60,000 to 120,000, depending on the length of the tools.

Inasmuch as all this adds to the cost of the tools and since live line work is slower than work on de-energized lines, one might wonder whether live line work is economical. Respecting this, if you consider that a mile of double circuit line which provides two sources of supply to a customer, neither one of which is deemed to be as reliable from an overall service point of view as a single circuit of the type now being built costs about $5,300, and that the latter costs about $3,200, we have a capital saving per mile of $2,100. Assuming 10 per cent for all charges, $210 per mile per year could be spent on maintenance and still show the same overall annual cost. With this in mind, a capital investment of $600 for a set of tools which will serve for many miles of line is really a modest expense. As a matter of fact, some types of work can be performed more economically on a live line than on a de-energized one. This is particularly true in the case of replacing insulators, pins, etc., since only one trip to the job is required and no switching is necessary. If such work were done on a de-energized line it would be necessary to make arrangements for service interruptions, to perform the switching, ground the line and obtain a work permit before work could be started; then after the work had been completed to repeat the procedure in reverse order before restoring service.

Our patrolmen carry certain tools in their trucks at all times which enable them to do such minor jobs as replacing a tie, an insulator, a pin, or replacing a broken crossarm at any time such defects may be discovered while they are on patrol, thus saving time and truck mileage.

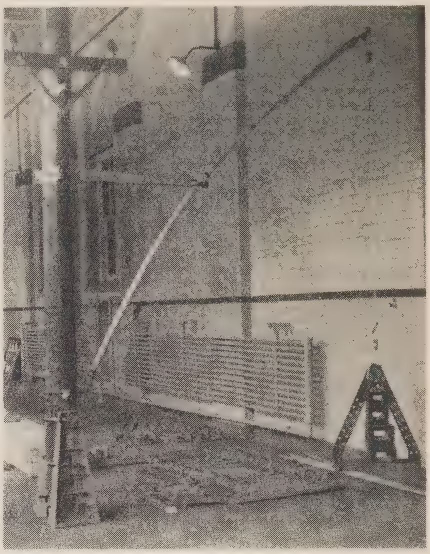

Fig. IV. Tools under mechanical test.

In our experience properly trained linemen of the right temperament take a greater personal pride in live line work than they do in ordinary line repairs on isolated lines, and, in general, they prefer to work on live lines. These facts lead them to think and to offer suggestions for tool improvement and for more efficient technique in handling the tools. This, in turn, together with the guidance of the supervisory staff has resulted in the development of methods for performing practically any type of live line work except making joints, and consideration is being given to this at the present time.

The use of our live line tools has been introduced by personal demonstration and instruction. This has been necessary since our experience with them

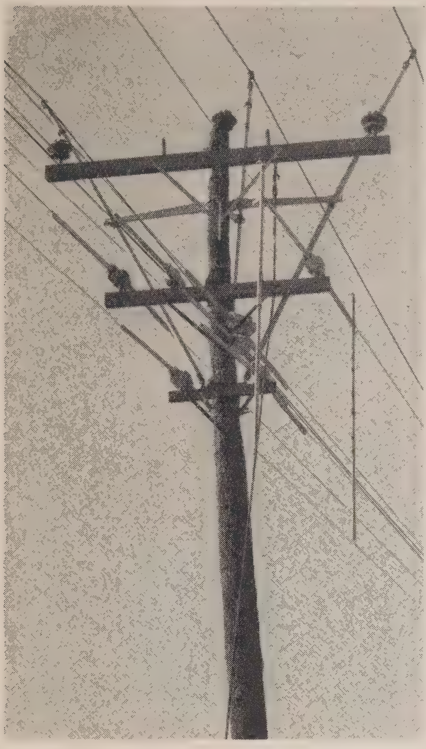

Fig. V. Conductors at three levels.

has not been broad enough to permit writing instructions which would be of any great value to inexperienced line personnel. It is our intention to develop and issue instructions, however, as soon as we have accumulated sufficient information regarding the most efficient methods of performing specified types of work.

The ideal line to work hot is one of single circuit with no other wires underneath, and though a telephone circuit generally hinders the work a little, it can readily be untied and moved if it is in the way. However, when the circuit to be worked has another power circuit underneath it, as is illustrated in Fig. V., the work is much more difficult and time consuming.

Among the types of work performed on live lines more or less regularly are the following:

1. Testing and replacing insulators.
2. Replacing insulator pins, or crossarms.
3. Replacing poles.
4. Removing the ground wire and changing from flat to pole top pin construction.
5. Diverting a line.
6. Extensive or continued work, for example, rebuilding a whole line, and changing from one type of construction to another.

Unfortunately we have no illustration of the insulator testing devices used by the Commission, but doubtless some of you are familiar with one or other of them. They are:

(a) Berry Live Line Insulator Tester.

(b) Hi-Pot Insulation Test Stick.

Either of these devices gives good results in the hands of trained testers and it may be of interest to you to know that both of them were developed by employees of The Hydro-Electric Power Commission of Ontario.

Since time will not permit describing the operations involved in the performance of all the types of work, I will deal briefly with one of the fundamental jobs and one or two of a more unusual nature.

One of the most common operations involved in live line work is the removing and the replacing of insulator ties to permit changing insulators, replacing insulator pins, replacing crossarms, etc.

Standard wire ties can be made or removed with live line tools but the procedure is somewhat difficult and

Fig. VI. Tie wire being removed.

slow, Fig. VI. We have experimented with several designs of bolted clamp types of ties which afford a distinct saving of time in tying in conductors. Moreover, such ties will withstand a pull of approximately 800 lb. as compared with about 100 lb. for a wire tie. Two types of the clamps are shown, both of which have proven satisfactory in application and service. The one which we are using more generally is shown on the left in Fig. VII.

No elaboration is needed to make it plain that the clamp type of tie, which is applied with a socket wrench designed for the purpose, is vastly superior to the ordinary wire tie insofar as live line maintenance technique is concerned.

The replacement of an insulator in a live line, Fig. VIII, is a relatively simple job which can be performed in a very short time by experienced live line workers who have been provided with proper equipment and insulators equipped with clamp ties. It is merely necessary to attach the tools, open the two clamps, shift the conductor to provide safe working space, and proceed with the act of replacing the insulator. The

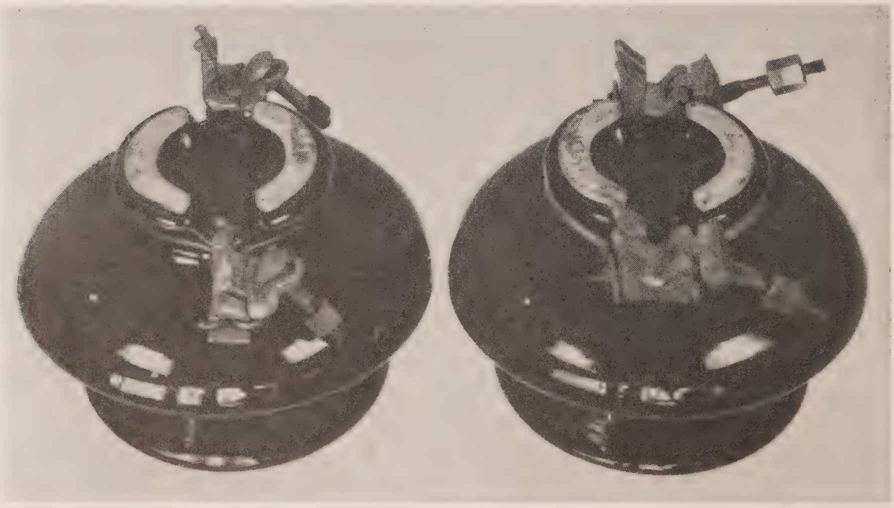

Fig. VII. Clamp type insulator ties.

Fig. VIII. Replacing an insulator.

reverse process of replacing the conductor on the new insulator is just as simple as removing it from the defective insulator. While, as you see, this job is simple, it accounts for much of the all round live line work due to the breakage of insulators through the agency of lightning, rifle shot, stone throwing, etc.

If every job were as elementary as replacing an insulator on a pole which supported only one set of conductors live line maintainance problems would be of little general interest. As is well known, however, the Commission endeavors to make the most efficient use of all of its poles and a great many of them support distribution and telephone conductors as well as transmission conductors. For work on the upper conductor levels the lower conductors must be isolated and de-energized, guarded, or set out of the way by live line tools so as to permit the lineman all the freedom he needs while concentrating his attention to the work in hand.

These conditions can be dealt with effectively and conveniently in the case of telephone circuits and power circuits of a phase to phase voltage not exceeding 5,000 by the use of the well known hose and hoods applied by the workmen using rubber gloves. See Fig. V.

The problem is more difficult, however, when higher voltages are involved. Adequate barriers must be provided, or the conductors must be moved to establish safe working space, or the secondary circuits must be interrupted and de-energized. The use of rubber gloves on circuits exceeding 5000 volts between phases is deemed to be unsafe and this precludes the use of hose and hoods on 8 kv. circuits, although it is believed such devices would afford protection if they could be safely attached and were tested periodically to ensure that substandard equipment would never be relied upon for protection. At the present time we are investigating live line tools for attaching and removing hose and hoods and are hopeful that we can overcome the problem of safeguarding live line work involving 8 kv. circuits by this means. This would leave still to be solved the problem of guarding the higher voltage distribution circuits and the only remedy in sight for this seems to be isolation or offsetting such circuits by means of live line tools.

It is obviously unduly expensive to offset two sets of wires to work on one

Fig. IX. Diverting a line. Moving the conductors to a new location.

circuit or one wire of the top level. Here is where the line designer can help by the use of special arms with wide climbing clearance or by the use of bolted line ties on the lower circuit, and preferably on both. This is of more than passing interest to municipalities since quite a number of municipal circuits or parts thereof are supported on poles which also carry the high voltage power circuit to the municipality.

Some years ago we had to divert a few spans of 22 kv. line approximately 30 ft. for highway construction. It could not be interrupted conveniently so plans were made to move it alive.

Fig. IX shows one of the new poles in the diverted location and one of the conductors being transferred to its new position. The erection of the new poles was, naturally, the first step of the work. In locating them care had to be taken to ensure that the sag would be normal after the conductors had been transferred from the old right-of-way to the new, since they could not be cut.

After the poles had been erected and fitted with insulators, etc., the necessary live line tools to control the movement of the conductors were attached as shown here. The several small gangs of live line workers who were engaged in the work were able by means of the equipment which appears in the illustration to guide the conductors to their new positions without incident.

The appearance of the old and the new poles after the conductors had been transferred is shown in Fig. X.

The work was carried out during ordinary working hours, and no customer was interrupted. If it had not been possible to accomplish the diversion of the line by means of live line tools a number of poultry farm customers who had incubators in service would have suffered an unavoidable interruption of several hours.

Another interesting and difficult piece of work which was performed more recently involved the rebuilding of approximately eight miles of 26 kv. line on the edge of possibly one of the

Fig. X. Diverting a line. After the conductors had been moved.

busiest highways in the province, between Richmond Hill and Aurora. Unfortunately, no photographs were made during the course of the work. However, Fig. XI will indicate fairly clearly the magnitude of the job.

The line, which was constructed in 1911, formerly belonged to the Tor-

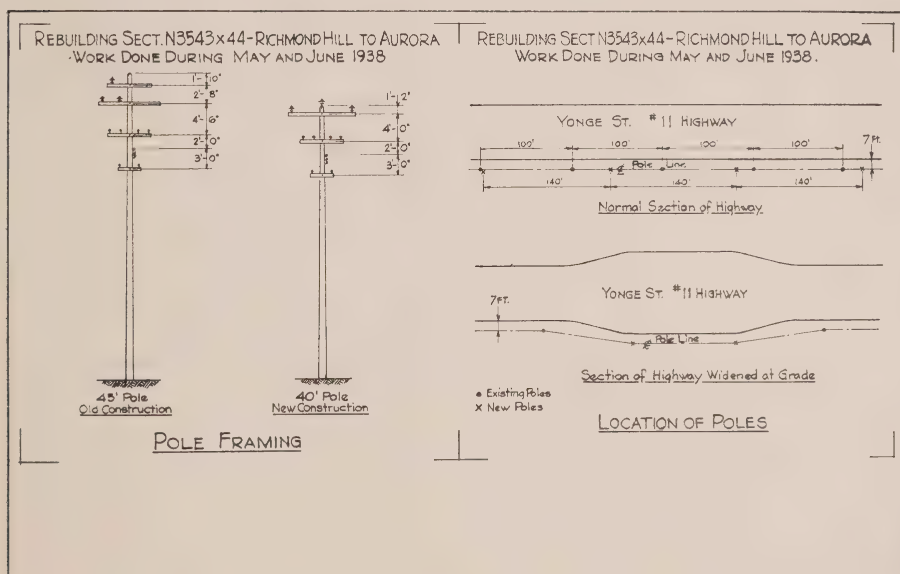

Fig. XI. Rebuilding a 26 kv. line.

onto Power Company. It consisted of a single circuit of No. 00 copper on one side of double circuit framing at the top of the pole, 4 kv. primaries, secondaries, and a telephone circuit arranged below. The spans were 100 ft. and the poles were, in general, of 45 ft. length.

It was decided to convert the line to pole top pin construction but the job was extended and complicated by several 10 ft. to 15 ft. diversions to accommodate changes being made in the highway.

Since it would have been extremely difficult to obtain interruptions to the 26 kv. circuit plans were made to work the line "hot". Fortunately, it was possible to isolate the primaries without creating major service problems, but in order to do this it was necessary first to install a number of sectionalizing cut-outs at various points.

New 40-ft. poles were erected for 140 ft. spans and by means of live line tools the conductors were freed from the old pole and raised or shifted laterally as necessary to provide safe working space for framing the new poles. The tools and conductors were then transferred to the new poles and the old poles taken down before the conductors were attached to the new cross-arm.

Certain corner pole construction presented some difficulties but it was possible to transfer the conductors from the old to the new location without mishap. The entire job was carried out without accidents and with only two short early morning interruptions to make cutovers involving the lengthening of conductors at diversion points.

When planning maintenance work, as when considering capital expenditures, the cost must be given careful consideration and this can readily be done, but in maintenance there also is to be considered the matter of the customer's convenience which, as you will understand, often is of greater importance than the cost. This, of course, has a bearing on the methods to be used in the work and since live line work saves all or most of the interruptions, it is to be preferred wherever practicable. Actually, on the North Yonge Street job, (Richmond Hill to Aurora) above referred to, the cost is estimated to have been only from 20 to 25 per cent higher than if it had been done during interruptions, an increase, in the circumstances, we thought well warranted.

We have not had a single serious accident to a lineman engaged in the use of live line tools, nor have we had any serious service impairment as a result of mishaps. On two or three occasions conductors have flipped together in transposition spans while the conductors were being elevated or lowered, and several interruptions have been caused when tie wires which were being removed touched a cross-arm while in contact with the line, but in all cases the duration of the interruption was confined to the time necessary for the lineman to contact the operator at the controlling station and assure him that it would be in order to re-energize the line. Incidentally, we insist on close co-operation between linemen engaged in live line work and operators. The lineman must obtain the consent of the operator who attaches a warning tag to the device controlling the line before giving his consent to the work. If this line should

be isolated automatically, for any reason, during the course of the work, it is not re-energized before communication has been established with the line gang, or before a time interval as prearranged beforehand has elapsed.

Our experience confirms that of other organizations that live line tools are an indispensable aid to the maintenance of any important transmission system, and while we may scarcely consider ourselves beginners, we have much to learn in the complete and effective application of these tools to our work. We hope to greatly improve the tools themselves and to further develop the art of their safe and efficient use.

"Porcelain"

As porcelain is of so great importance as an electrical insulating material, the origin of the name may be of interest to some readers of *The Bulletin.*

The large family of seashells, known as Cypræidæ, are ovate in shape or cylindrically oblong. They are mostly smooth and very highly polished. The aperture runs the full length of the shell and is definitely toothed. These are the most beautiful of shells and the most diversified in their colouring. They also vary considerably in size.

One species in this family, the "Tiger Cowry" *(Cypræa Tigris)*, is quite commonly seen as a curio in many of the older homes, and is supposed, when held to the ear, to reproduce the roar of the sea.

It was thought in Italy that some of these shells resembled young pigs, and so they were given the corresponding name, "porcellana", derived from the Latin root, "porcus", a hog,—obviously also the root of our own word "pork".

The pottery produced in Japan and China until the end of the fifteenth century was of two main varieties, the opaque coloured earthenware and the white translucent kaolinic ware, made chiefly with kaolin, commonly known as China clay. From the early part of the sixteenth century until the beginning of the eighteenth, attempts were made in Italy and France to reproduce this translucent ceramic material and consequently chinaware was studied closely.

The Chinese products and the results obtained in Italy had the same smoothness and high glaze as the seashells of the Cypræidæ family and consequently the material, and the articles made of it, were soon designated "porcellana" also. From this name, then, our present word "porcelain" is derived.

It has been said that in the abattoir every part of the hog is used except the squeal but the electrical industry evidently is memorializing his form and outline, and there is this distant connection between our high voltage insulation and our bacon.

Our Industrial Customers

By W. R. Harmer, Supervising Industrial Engineer, H.E.P.C. of Ontario

WORLD War No. 2 has been blamed for a great many things, but it has brought industrial power loads again into a position of supreme importance. This war's final outcome will be hastened by the ability of our industries to produce in sufficient quantities those munitions and supplies so essential to this mechanical war.

Our industrial customers have many production difficulties that we know nothing about. They look to us, and expect us to make their job possible by supplying them with electrical energy when they need it, and in any quantity to meet their requirements. Supplying this power is essentially our problem, and Hydro's record of achievement in maintaining adequate supply is something of which we can all be proud. However, our obligations do not end when we deliver power to the customer's transformers or service switches. It is of equal importance to us to make sure that the best possible use is made of the available supply of power. It is not now a question of dollars and cents obtained for our power, but a matter of co-ordinating generating capacity, distribution facilities and use of power to make every available kilowatt-hour exert its full energy in the production of essential products.

Whose duty is it, and who is responsible for accomplishing these results? As in the case of the war which is now being prosecuted by each and every free democracy, so in this is it necessary for each and every one who has any association with Hydro, be they Utility or Hydro-Electric Power Commission employees, to make sure that there is absolutely no stone left unturned in our effort to ensure that available power is not wasted. It is our job to keep our industrial customers fully advised of developments in the power demand and supply situation, and to seek their co-operation in eliminating all unnecessary energy losses, both in our lines and in their own plants.

This can be accomplished by closer contacts with the managers, superintendents and maintenance men in every plant throughout the Province; by using these contacts to explain the various factors which cause excessive loss; and by showing each one how these losses can be eliminated in their own particular plant.

In this short paper, I would like to outline some of the larger and more important of these unnecessary power losses common to industrial plants, and to suggest some means of reducing these losses.

Probably the largest single item contributing to unnecessary loss of electric power is low power factor. A technical description of power factor is quite complicated, but I think more people could get a clearer understanding of the term, and thereby better grasp the effect of low power factor if we make use of this non-technical simile. Compare our own or our cus-

Presented to the Association of Municipal Electrical Utilities at Toronto, February 10, 1942.

tomer's electrical system to a glass of beer. The conductors can carry so much current just as a glass can hold so much beer. If the power factor of the system is 100 per cent, then all the current carried does useful work, and it can be compared to a glass filled to the top with beer alone. If the power factor on the system is 50 per cent, it corresponds to a glass containing one half beer and one half froth. We know that the froth on the beer is of no use except to fill up the glass, so also 50 per cent of the current in the lines does no useful work but does load up the conductors, transformers, etc. with worthless current. We pay just as much for this beer and froth as we would for a full glass of beer. Similarly, our customers pay for the full line current, even though it is only doing one half the useful work it could do with the power factor at 100 per cent.

As an example of how low power factor increases losses, consider a 550 volt, 3 phase circuit supplying a 300 kw. load at 60 per cent power factor. The line current would be equal to 525 amperes (of which only 315 amperes would be power producing current). If the load power factor were improved to 90 per cent, the line current would be reduced from 525 to 350 amperes. Since copper loss varies as the square of the current, it is evident that the line loss at 60 per cent power factor is $\left(\frac{525}{350}\right)^2$ or 2¼ times the loss at 90 per cent power factor. This relation holds for any circuit with the above power factor conditions.

This example also has a corollary. By improving the power factor of the load from 60 to 90 per cent, it would be possible without overloading, to add an additional 150 kw. of 90 per cent power factor load to this circuit.

In these days of rapid load growth, and difficult priority ratings, it may well be that improving the load power factor may sufficiently relieve heavily overloaded circuits, or make possible the addition of greater loads to existing circuits, and thus eliminate the necessity of purchasing new or larger transformers, switches and conductors.

Very closely associated with the losses due to low power factor are the losses resulting from underloaded induction motors. In fact, one of the main causes of low plant power factor is this same underloaded motor. If the penalties of operating induction motors at considerably less than their nameplate rating were made apparent, more attention would be given to the correction of this evil.

The following data refer to individual motors. In the case of a complete plant load where the power factor is above the minimum set by Hydro regulations, the difference in efficiency only should be considered in these calculations.

The h.p. input to a motor, which is the quantity of power we have to supply —and our customer pay for—is equal to the h.p. output, divided by the power factor and by the efficiency of the particular motor. When a motor is fully loaded it has an efficiency of say 87 per cent and a power factor of say 89 per cent. (Refer to Figs. 1 and 2.) The input then would be equal to

$$\frac{100}{89} \times \frac{100}{87} \times \text{ output,}$$
$$\text{or } 1.29 \times \text{ output.}$$

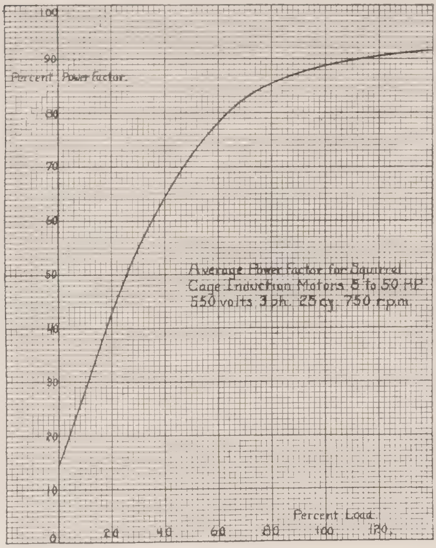

Fig. 1

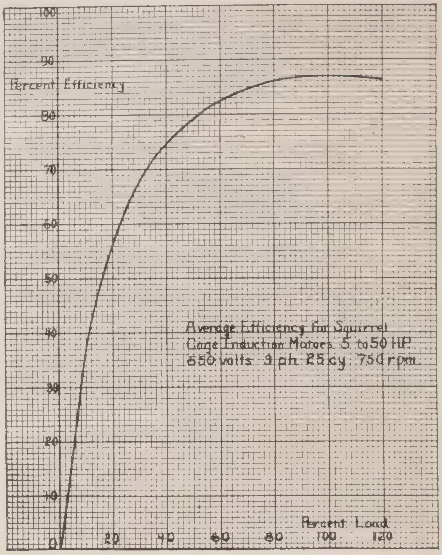

Fig. 2

However, we normally permit a power factor as low as 90 per cent without penalizing the customer, so we will use the billed h.p. as the basis of comparison.

$$\text{i.e. Billed input} = \frac{90 \times 1.29}{100} \text{output}$$
$$= 1.16 \times \text{output.}$$

Suppose this motor is now operated at 40 per cent of its rated horsepower output. From the average curves the power factor would be about 64.3 per cent and the efficiency 74.5 per cent.

Then billed input is equal to

$$\frac{90}{64.3} \times \frac{100}{74.5} \times \text{ output,}$$
$$\text{or } 1.88 \times \text{ output.}$$

This is an increase of 62 per cent $\left(\frac{1.88 - 1.16}{1.16} \times 100\right)$ in the horsepower input per h.p. delivered.

To emphasize this point further, suppose one of our customers has two planers which are identical in size and require 10 h.p. to drive them when under full load. One of these planers has a 10 h.p. motor and the other is driven by a 25 h.p. motor.

From the above figures the billed input to the 10 h.p. motor would be $1.16 \times 10 = 11.6$ h.p.

The billed input to the 25 h.p. motor would be $1.88 \times 10 = 18.8$ h.p. or a difference of 7.2 h.p. in the demand of the two motors for the same amount of useful work done.

This means that we are required to supply, from our already overloaded generators, 7.2 h.p. which does no useful work for us or our customers. Multiply this figure by the hundreds of actual cases of underloaded motors in Ontario today and you can realize the importance to us of correcting this unnecessary loss.

What does this mean to our customers? Taking into account the initial

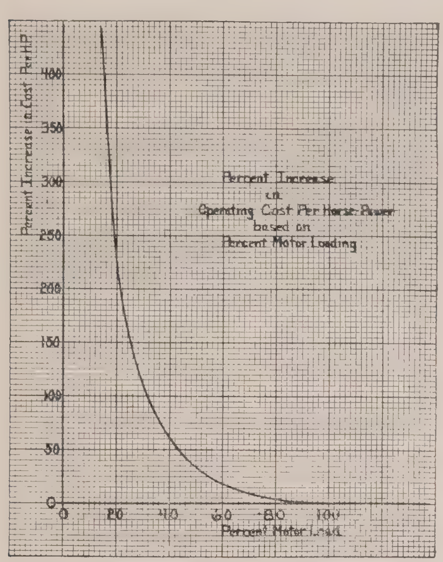

Fig. 3

investment, fixed charges, and operating costs of these two motors it means that our customers pay approximately $170 extra per year for using a 25 h.p. motor on a job requiring a 10 h.p. motor.

You may think that this illustration is exaggerated, but in a survey of well over 100 industrial plants we found that 25 per cent of the motors tested were operating below 40 per cent of their nameplate rating.

In Fig. 3, you can see in graphic form *the per cent increase in operating cost per output horsepower* for motors operated at less than their full load rating. This same curve can represent the *per cent increase in the input horsepower demand per output horsepower* for loads of less than 100 per cent of motor nameplate rating.

A source of energy loss often overlooked is that due to low voltage. We have a good record as far as supplying and maintaining rated voltage is concerned; but the effects of low voltage should be brought to the attention of our industrial customers.

In any circuit a normal voltage drop is to be expected, but when this drop amounts to, say 10 per cent of the supply voltage, its effect on lamp output or motor torque is startling. For example, 115 volt lamps operating in a circuit of 105 volts only provide 73.5 per cent of their normal output of light, and yet are burning 87 per cent of their normal current. This is equal to 13.5 per cent wasted energy. The torque of an induction motor is proportional to the square of the applied voltage; a difference of 10 per cent between terminal and nameplate rated voltage therefore means a reduction of 19 per cent in motor starting or running torque. It also means an increase of 11 per cent in motor full load current, which is equivalent to a 21 per cent increase in copper loss.

What steps can be taken to reduce or eliminate the losses which we have outlined?

The one basic remedy is to improve power factor. This can be accomplished in a number of practical ways:

(a) Eliminate underloaded induction motors.

(b) Replace overloaded circuits.

(c) Combine power and lighting loads.

(d) Increase resistance loads such as electric ovens.

(e) Use synchronous motors at unity or leading power factor to drive large constant load machines e.g. air compressors.

(f) Install power factor corrective equipment, such as, capacitors or synchronous condensers.

Items (b) (c) (d) (e) and (f) are almost self-explanatory but I would like to enlarge somewhat on item (a) —Elimination of underloaded induction motors.

The proper time to eliminate the possibility of losses due to underloading is when the motors are being installed. Machine manufacturers are placing more and more emphasis on the proper type and horsepower of the motor for a particular job or machine. However, even on new equipment industrial plants should check this by making a load test on the motor as soon as it has been installed.

The main problem involves the checking of motors already installed. In a plant where they have no recorded list of motors, the first step is to make a survey and list all the plant motors. This list should contain motor application and complete nameplate rating. The next step is to make a load test on each motor; this should include voltmeter, ammeter and wattmeter readings taken with the machine operating at normal load and at maximum load.

From these results it is possible to calculate the motor power factor, motor output horsepower, and per cent of motor loading. With these load data available for all the motors it is possible to get an overall picture of the motor situation in the plant. An overloaded motor in one section need not be discarded and a larger motor purchased, neither need an underloaded motor in one section be discarded and a smaller motor purchased. A systematic rearrangement of the motors within the plant can often be made and great improvements effected without the purchase of a single new motor.

Here is an example of how it works out:

MOTOR DATA

Application	Name-plate h.p.	Load h.p.	% Loaded
Spinning dept.	40	24	60
Cotton carders	30	14	46
Woollen mules	20	15	75
Woollen carder	10	4	40
Woollen carder	10	4	40
Mule	5	4	80
Weaving	20	8	40

A study of these loadings show that a rearrangement of motors could be made as follows:

(1) Replace the 40 h.p. motor, spinning department with the 30 h.p. motor on the cotton carders.

(2) Replace the 20 h.p. motor on the weaving with one of the 10 h.p. wool carder motors, and install this 20 h.p. motor on the cotton carder.

(3) Combine the wool carders and drive both with the other 10 h.p. motor.

(4) Leave the 5 h.p. and 20 h.p. mule motors alone.

This eliminates the 40 h.p. spinning department motor, which can be sold, or used as an emergency spare. The net result is therefore a reduction of 40 h.p. in the connected load of the plant and an estimated reduction of 20 h.p. in demand.

We know that there is at present a limit to the power which is available. But let us work hard to avoid the necessity of saying to an industrial customer,

"Sorry, we have no more available power."

Let us be able to say "Yes, Jones and Co. next to your plant have just re-

duced their demand by improving their power factor. We can supply you with power from the same transformer bank which feeds them."

Every kilowatt of load that is added now for the manufacture of essential supplies, means that we can finish the "job" more quickly. It also means more kilowatt-hours which industry will continue to buy from us, when this war is over.

We can be of great assistance to our industrial customers by helping them to realize the magnitude and importance of these unnecessary power losses, and by showing them how they can be eliminated. It means savings to them in money; it means savings to us through improved power factor, and it means savings in power demand and consumption which can be used effectively to do additional war work.

The Winter Conventions

THE Winter Conventions of the Ontario Municipal Electric Association and of the Association of Municipal Electrical Utilities which were held jointly at Toronto on February 10th and 11th, 1942, made an all time record as to the number of delegates and attendance at sessions. There were 863 delegates registered not including visitors who brought the total register well over 900.

In the previous number of this publication and also in this issue are some of the addresses and papers given during the Conventions as also other reports.

* * * *

O.M.E.A.

During the proceedings of the Ontario Municipal Electric Association Convention the following resolutions were adopted:—

"THAT the Incoming Executive consider the regrouping of Hydro Municipalities with a view to decreasing the number of Districts into which the Ontario Municipal Electric Association is divided."

"THAT no Summer Convention be held this year."

"THAT the Municipalities of Rosseau and Powassan, on account of their location, be transferred to Georgian Bay District No. 2."

"THAT a Committee be appointed by the Ontario Municipal Electric Association to co-operate with The Hydro-Electric Power Commission of Ontario to plan effective means of conserving power and to properly inform the public as to the need for conserving power."

"THAT our Constitution be amended by adding to the Executive, the office of Immediate Past President."

"THAT it is the opinion of this body that we should ask the Power Controller to make a further survey of the farm situation in Ontario, and try if possible to assist the farmer and allow him the use of more power. This resolution to be sent on to The Hydro-Electric Power Commission, and by them to the Power Controller."

Officers and Directors elected for the year 1942 are:—

Honourary President—Dr. T. H. Hogg, Chairman, Hydro-Electric Power Commission of Ontario, Toronto.

Honourary Vice-Presidents—T. W. McFarland, London; Jos. Gibbons, Toronto; F. Biette, Chatham; G. S. Matthews, Peterborough; C. J. Halliday, Chesley; John Kalte, Hanover.

President—K. A. Christie, K.C., Toronto.

Past President—Dr. W. J. Chapman, St. Catharines.

Vice-Presidents—

District No. 1—W. R. Strike, Bowmanville

District No. 2—A. Menary, Grand Valley

District No. 3—Dr. M. P. Benger, Port Arthur

District No. 4—A. G. Jennings, East York

District No. 5—K. C. MacLeod, Stamford

District No. 6—H. O. Hawke, Galt

District No. 7—P. R. Locke, St. Thomas

District No. 8—G. A. Edwards, Windsor

District Directors—

District No. 1—Jas. Halliday, Kingston; M. P. Duff, Belleville.

District No. 2—R. D. Boyes, Alliston; W. V. Brown, Meaford.

District No. 3—J. R. Pattison, Fort William; C. H. Moors, Fort William.

District No. 4—W. C. Andrews, Streetsville; (one other to be appointed).

District No. 5—R. Pierson, Brantford Twp.; C. D. Hanniwell, Niagara Falls.

District No. 6—F. H. May, St. Marys; F. E. Welker, St. Jacobs.

District No. 7—J. B. Hay, London; B. N. Downing, Beachville.

District No. 8—Chas. Austin, Chatham; A. P. St. Louis, Riverside.

Secretary-Treasurer—Miss K. Ciceri, Guelph.

* * * *

A.M.E.U.

Pursuant to the address by the Metals Controller of Canada and the series of convention addresses on Problems Resulting from the War, a resolution was adopted empowering the incoming president to appoint a chairman who in turn would name other members of a special committee to assist in war work.

The following officers for the year 1942 were elected:—

President—V. A. McKillop, London

Vice-President—R. B. Chandler, Port Arthur

Secretary—S. R. A. Clement, H.E.P.C. of Ontario, Toronto

Treasurer—G. E. Conn, H.E.P.C. of Ontario, Toronto

Directors (from the membership at large)—

A. W. Bradt, Hamilton

A. B. Manson, Stratford

O. C. Thal, Kitchener

District Directors—

Niagara District—R. S. Reynolds, Chatham

Central District—C. A. Walters, Napanee

Georgian Bay District—R. S. King, Midland

Eastern District—W. B. Reynolds, Brockville

Northern District—C. J. Moors, Fort William

At a meeting of the Executive Committee held during the Convention, Standing Committees were appointed as listed Below:—

Papers Committee—A.W. Bradt, Hamilton, Chairman; G. E. Chase, Bowman-

ville; R. S. Reynolds, Chatham; C. E. Schwenger, Toronto; C. W. Hookway, Canadian Westinghouse Co., Toronto; H. D. Rothwell and M. J. McHenry, H.E.P.C of Ontario, Toronto.

Convention Committee—R. B. Chandler, Port Arthur, Chairman; R. L. Dobbin, Peterborough; F. A. Mahoney, Canadian General Electric Company, Toronto; E. G. McCracken, Sangamo Company, Toronto; W. Dixon, Canadian Westinghouse Company, Toronto; J. A. Clish, Northern Electric Company, Toronto; A. H. Frampton and T. C. James, H.E.P.C. of Ontario, Toronto.

Regulations and Standards Committee—O. C. Thal, Kitchener, Chairman; R. B. Chandler, Port Arthur; S. W. Canniff, Ottawa; P. B. Yates, St. Catharines; O. H. Scott, Belleville; R. L. Dobbin, Peterborough; T. R. C. Flint, Toronto; W. R. Catton, Brantford; A. B. Manson, Stratford; C. J. Moors, Fort William; A. G. Hall, W. P. Dobson and J. J. Jeffery, H.E.P.C. of Ontario, Toronto.

Committee on Accident Prevention and Health Promotion—R. S. King, Midland, Chairman; R. J. Smith, Perth; P. B. Yates, St. Catharines; C. E. Schwenger, Toronto; J. W. Peart, St. Thomas; R. Harrison, Scarborough Twp.; V. A. McKillop, London; R. L. Dobbin, Peterborough; A. B. Manson, Stratford; A. W. Murdock, B. Mulholland, V. A. Beacock and Wills Maclachlan, H.E.P.C. of Ontario, Toronto.

Merchandising Committee—R. S. Reynolds, Chatham; Chairman; O. H. Scott, Belleville; F. S. Rhoads, Windsor; R. W. Turner, Hamilton; H. R. Hatcher, Galt; A. W. J. Stewart, Toronto; O. C. Thal, Kitchener; F. Wilkinson, London; E. Parsons, Sarnia; N. Robinson, Stratford; S. W. Canniff, Ottawa; R. L. Dobbin, Peterborough; J. W. Peart, St. Thomas; W. Dymond, J. A. Blay, J. J. Jeffery and M. J. McHenry, H.E.P.C. of Ontario, Toronto.

Rates Committee—A. B. Manson, Stratford, Chairman; P. B. Yates, St. Catharines; G. E. Chase, Bowmanville; W. R. Catton, Brantford; O. H. Scott, Belleville; D. E. Charters, Windsor; R. S. Reynolds, Chatham; T. R. C. Flint and F. W. Peasnell, Toronto; A. W. Bradt, Hamilton; R. L. Dobbin, Peterborough; J. J. Jeffery, G. F. Drewry and S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Committee on Accounting and Office Administration—C. A. Walters, Napanee, Chairman; Geo. Appleton, Toronto, Vice-Chairman; R. S. King, Midland; H. R. Hatcher, Galt; A. B. Manson, Stratford; J. W. Hammond, Hamilton; W. E. Wallace, Windsor; C. W. Eastwood, London; P. E. Battram, Sarnia; A. M. Bowman, Elmira; A. E. Ditchburn, Strathroy; T. W. Houtby, Welland; W. H. Gibbie, Oshawa; H. Clegg, Peterborough; A. D. Nelson, Kingston; O. H. Scott, Belleville; Wm. Tait, Picton; W. M. Salter, Barrie; G. W. Grabb, Chesley; R. H. Martindale, Sudbury; and R. M. Bond, H.E.P.C. of Ontario, Toronto.

Auditors—H. P. L. Hillman, Toronto and W. G. Pierdon, H.E.P.C. of Ontario, Toronto.

A.M.E.U. Committee Reports

Rates Committee Report

By P. B. Yates, Chairman

The A.M.E.U. Rates Committee held two meetings during the past year, one at St. Catharines on Thursday, June 5th and one at Hamilton on Thursday, July 10th.

The report of this committee adopted at the convention in Toronto in February, 1941 was reviewed and some details discussed.

Fluorescent and Electrical Discharge Lamps

In the discussion on the report at the convention, advice was given of action being taken by the Canadian Electrical Standards Association requiring labelling of such lamps. The final draft of the C.E.S.A. specification C22.2, Electric Fixtures, C.E. Code Part II Specification 9, Clause 61, is as follows:—

"The manufacturer's name, trademark or other recognized symbol of identification shall be marked on each fixture in a permanent manner where it can be readily seen and, in addition, in fixtures having fluorescent lamps or similar types of electrical discharge lamps the marking shall include also the rating in volts, total amperes, power-factor, and frequency. In general, marking shall comply with the requirements of Specification C22.2 No. 0—"Definitions and General Requirements"—of Part II of this Code."

As for billing for fluorescent lighting, the committee was advised that the H.E.P.C. was instructing utilities to bill in the same manner as for Neon signs.

It was suggested that the procedure outlined by the H.E.P.C. governing billing for Neon signs be simplified and a proposed revision submitted. The suggestion is still under consideration by the committee.

Factory Lighting

The question was asked, if there is any dividing line showing the ratio between lighting load and power load under which commercial lighting rates must be used. The committee was of the opinion that there is no such dividing line and that Clauses 19 and 42 of the Standard Interpretations of Rates cover the condition.

When a consumer takes power under a day power contract and requires power for lighting only at night, the committee was of the opinion that such load should be supplied on a 24 hour unrestricted basis. The committee asked that the Hydro Commission prepare a ruling to be inserted in the Standard Interpretations of Rates to clarify the billing where lighting is used with a day power contract.

Intermittent Rated Equipment

Referring to Clauses 46 and 47 of the Standard Interpretations of Rates, "Intermittent Rated Equipment" and "Elevator Motors" which were reported under consideration for revision by the Commission's Rates Committee, progress was reported on the proposed revision. The performance of spot welders and similar loads both as to their detrimental effect on line voltage and to the small apparent load recorded on commercial meters compared with the

actual instantaneous demand or equipment rating is under consideration. A study is being made of records and tests of welder installations served by some of the utilities for consideration by the committee. It was reported that a peak-watt meter had been newly developed which it was hoped would meet the approval of the National Research Council.

Infra-Red Heating

The committee was advised that infra-red heating is treated by the H.E.P.C. as an industrial appliance.

Store and Dwelling Attached

It was suggested that Clause 15 of the Standard Interpretations of Rates be revised by the insertion of the words "may be" after the word "bills", making the clause read:—

"A dwelling with a business premises having more than 500 watts permanently connected in the same building and occupied by the same party, and where the wiring does not permit the use of two meters, one meter may be installed, and two bills may be rendered by apportioning the kilowatt-hours used in accordance with the installed capacity in such service. If the business premises has less than 500 watts permanently connected, one bill may be rendered at the domestic rates."

Electric Service Included in Rent

Where there are a number of families in one house, and electric service is supplied in the rent, it was ruled that the landlord should be billed on commercial lighting rates with a demand meter installed.

Motor Load at Commercial Lighting Rates

Referring to Clauses 18 and 19 in the Standard Interpretations of Rates, under Commercial Lighting Service, the question was asked:—"Wherein lies the justice, under present conditions, in requiring that the motor load shall exceed the lighting load to qualify for a power rate."

It was pointed out that the tendency was to make the commercial lighting rates and the power rates to approximate one another on long hour use so that there would not be any great difference in the bill by using one rate or the other. Under certain conditions of short hour use, the commercial lighting rates are the cheaper.

Churches

It was ruled that by Clause 27 of the Standard Interpretations of Rates, a church is entitled to one-half of the commercial lighting rates for the church auditorium only, when it is used exclusively for church services. If the church auditorium is used for other purposes as well as church services, it should be billed at the full commercial lighting rates as required for all other parts of the church property.

It is the opinion of this committee that The Hydro-Electric Power Commission should revise the Standard Interpretations of Rates to agree with the modifications which have been made since the last issue was printed, as of July 1st, 1937.

Report of Committee on Accident Prevention and Health Promotion

By R. J. Smith, Chairman

This Committee has not held meetings during the past year on account of war conditions.

We have to bring to your attention the number of serious accidents which have been happening to experienced line men. The only way in which these accidents can be accounted for, is by men not keeping their minds on the job, particularly when working in close quarters. Workmen should have properly balanced meals and at least eight hours' sleep each night, to keep in the best physical condition, to perform their work safely.

The Medical Health Officers of the Province are doing a splendid job in eliminating diphtheria and scarlet fever, by the toxoid treatment. Workmen with small children, should have them inoculated against these diseases, before the end of their first year. The inoculation is safe, has no reaction and in the case of diphtheria, 100 per cent effective. It would be difficult for a workman to keep his mind on his work, with a sick child at home.

You will have the pleasure of hearing a paper on "Better Tools for Hydro Rural Lines" by E. R. Lawler, Assistant Engineer, Municipal Engineering Department of The Hydro-Electric Power Commission of Ontario, on Wednesday afternoon. These tools have been developed by the members of the Live Line Clamp Committee of the Commission and are being used by seventy-five rural power district operating centres. They may be made available for use of municipal Hydro systems, at a later date. Only experienced Class A linemen are trained in the use of these tools.

Your Committee wishes to point out the particular necessity, at the present time, for the care of rubber gloves, linemen's belts and spurs and rope, especially hand lines; this is due to the fact that it is extremely difficult to obtain these pieces of equipment. Some of them can only be obtained by getting a priority. We are faced with the possibility of manilla rope being taken off the market. The other ropes available have only 80 per cent of the strength of manilla and to get equal strength in hand lines, we would have to use a large line.

Report of Merchandising Committee

By R. S. Reynolds, Chairman pro tem

The A.M.E.U Merchandising Committee held a meeting on November 21st, 1941, which was an adjourned meeting called some time previously but cancelled owing to the untimely death of the chairman, O. M. Perry of Windsor, Ont. R. S. Reynolds of Chatham, Ont., was appointed temporary chairman to complete the balance of the year.

At the meeting the various regulations, as recently passed by the Dominion Government, covering installment purchasing and price control, were outlined to the Committee. Some of these were still not definite as to their interpretation and considerable discussion took place covering their many points

and application to Hydro Shop operation. The Sales Promotion staff of The Hydro-Electric Power Commission are endeavouring to keep posted up to date in respect to these regulations and interpretations can be obtained from them upon request at any time.

A number of other difficulties in the operation of Hydro Shops were discussed, such as, the difficulty in obtaining repair parts, the move on the part of some manufacturers to reduce the guarantee period on certain items of their equipment and the difficulty of obtaining high grade element wire for replacement of stove burner coils.

Mr. McHenry of The Hydro-Electric Power Commission Sales Department outlined the present situation as regarding the possibility of power supply and suggested what restrictions in respect to appliances might be expected. He also advised that the advertising program of the Commission for the coming year would be more an institutional character rather than promotional.

Attention was drawn to the fact that some electrical retail merchants groups in the Province were suggesting that Hydro Shops be closed for the duration of the war and their business would then be turned over to the private dealers. A long discussion took place on this point and took into account the fact that many Hydro Shops were doing a splendid job in servicing of appliances and the maintaining of present equipment in a good state of repair. Also discussed was the policy of bonusing and it was the opinion of the Committee that this should be reduced or curtailed as much as possible. This has since been suggested directly by The Hydro-Electric Power Commission to the municipalities.

The question of closing Hydro Shops was considered of such importance that a resolution was passed by the Committee with instructions to send it at once to the Executive of the A.M.E.U asking that the principle be opposed and this was done and a mail vote taken from the Executive of the A.M.E.U. The mail vote being favourable to the continued operation of the Hydro Shops as outlined in the resolution, on December 13th, I instructed M. J. McHenry of the Sales Promotion Department to prepare a Brief on this subject as discussed at the meeting. The Sales Promotion Department have a gathering of information along these lines over the past years and it will be brought up to date and consolidated in to the necessary Brief.

Since that time our information in the above respect has proved correct and a meeting of the electrical section of the Retail Merchants Association was held in Toronto and the committee appointed to take up the question of Hydro Shop merchandising and the possibility of their going out of business. All members of the Committee were advised of this fact and a close watch is being kept on developments along this line by the Sales Promotion Department of the Commission. Suggestions were requested from the various utilities combatting this principle and quite a number of letters have been received outlining their ideas and reasons for continuing to operate both in the maintaining and servicing of appliances and the sale of new articles.

Report of Committee on Accounting and Office Administration

By C. A. Walters, Chairman

The Committee held a meeting on November 5, 1941 at the offices of The Hydro-Electric Power Commission, University Avenue, Toronto, when the following arrangements were authorized:

Breakfast Meeting—Winter Convention

It was decided to hold a Breakfast Meeting at the Royal York Hotel on Wednesday, 11th February, 1942 at 8 a.m., at which a round table discussion would take place having as the general subject, "Collections Under Present Day Conditions". H. J. Offer of the Detroit Edison Company has been invited to be the guest of the Committee and will be present at this meeting.

The Breakfast Meeting will adjourn at 9.30 a.m. to the general Convention Hall, where the movie film prepared by the Detroit Edison Company entitled, "Collection of Delinquent Service Bills" will be shown. This film has been the subject of very favourable comments from "south of the border" where it has been shown on several occasions to representative groups of electric utility employees and officials.

It was also decided to arrange for a display of office equipment and supplies by representative manufacturing concerns during the time of the Winter Convention.

The following resolutions have been recorded for the further attention of the Convention:

1. That the Hydro-Electric Power Commission be requested to have a paper prepared, if possible, and submitted to the Convention in the very near future in which the matter of Accounting, particularly in reference to the preparation of the Commission's Annual statements, be set forth in such a manner that it can be placed on file in local offices for the general information of the local utility officials particularly interested.

2. That the sectional meetings formerly held under arrangements made by the Committee on Accounting and Office Administration, be revived and carried through and that the official support of the A.M.E.U. for these meetings be obtained.

3. Unemployment Insurance

That this Committee recommends that the A.M.E.U. respectfully request the H.E.P.C. of Ontario, to make further efforts to obtain a definite ruling from the proper authorities as to whether Public Utilities employees are exempt from Unemployment Insurance, providing the local commissions declare these positions as permanent. This ruling is desirable as at the present time it is quite evident that discrimination exists as between some local commissions and their employees in respect to the application of the provisions of the Act.

Municipal Loads, February, 1942

NIAGARA SYSTEM

25 and 66-2/3 Cycle

	H.P.	Population
Hamilton	158,816	163,768
St. Catharines	26,539	30,406
Trafalgar Twp.	464	V.A.

66-2/3 Cycle

	H.P.	Population
Bronte	178	P.V.
Oakville	1,123	3,869

GEORGIAN BAY SYSTEM

60-Cycle

	H.P.	Population
Alliston	337	1,700
Arthur	143	1,089
Barrie	3,865	9,521
Beaverton	200	941
Beeton	125	617
Bradford	182	1,041
Brechin	31	P.V.
Cannington	174	761
Chatsworth	74	333
Chesley	496	1,812
Coldwater	113	545
Collingwood	2,372	5,636
Cookstown	75	P.V.
Creemore	119	661
Dundalk	219	686
Durham	394	1,874
Elmvale	170	P.V.
Elmwood	65	P.V.
Flesherton	70	452
Grand Valley	107	645
Gravenhurst	1,197	2,261
Hanover	1,403	3,190
Holstein	185	P.V.
Huntsville	1,226	2,943
Kincardine	675	2,483
Kirkfield	27	P.V.
Lucknow	302	1,977
Markdale	166	776
Meaford	689	2,759
Midland	3,200	6,627
Mildmay	122	764
Mount Forest	447	1,936
Neustadt	48	431
Orangeville	671	2,558
Owen Sound	4,812	13,599
Paisley	136	730
Penetanguishene	981	4,177
Port Elgin	406	1,415
Port McNicoll	93	950
Port Perry	227	1,175
Priceville	10	P.V.
Ripley	76	420
Rosseau	34	305
Shelburne	216	1,053
Southampton	488	1,467
Stayner	224	1,106
Sunderland	74	P.V.
Tara	90	510
Teeswater	135	873
Thornton	24	P.V.
Tottenham	83	532
Uxbridge	297	1,480
Victoria Harbour	68	979
Walkerton	869	2,534
Waubaushene	74	P.V.
Wiarton	287	1,750
Windermere	20	117
Wingham	621	2,149
Woodville	81	439

EASTERN ONTARIO SYSTEM

60-Cycle

	H.P.	Population
Alexandria	223	1,976
Apple Hill	43	P.V.
Arnprior	1,109	4,019
Athens	99	626
Bath	32	325
Belleville	6,908	14,876
Bloomfield	91	636
Bowmanville	2,671	3,850
Brighton	308	1,462
Brockville	4,147	10,463
Cardinal	246	1,602
Carleton Place	1,663	4,143
Chesterville	293	1,094
Cobden	93	643
Cobourg	2,161	5,062
Colborne	188	960
Deseronto	163	1,002
Finch	80	396
Hastings	97	823
Havelock	143	1,103
Iroquois	211	1,123
Kemptville	361	1,230
Kingston	12,933	26,741
Lakefield	337	1,301
Lanark	87	686
Lancaster	49	570
Lindsay	3,418	7,241
Madoc	190	1,130
Marmora	128	1,004
Martintown	34	P.V.
Maxville	103	811
Millbrook	81	749
Morrisburg	216	1,484
Napanee	1,148	3,241
Newcastle	191	701
Norwood	146	710
Omemee	220	630
Orono	81	P.V.
Oshawa	18,992	25,035
Ottawa	33,875	150,277
Perth	1,654	4,197
Peterborough	11,949	24,400
Picton	952	3,400
Port Hope	2,238	4,997
Prescott	1,134	3,120
Richmond	72	428
Russell	68	P.V.
Smiths Falls	2,468	7,741
Stirling	240	947
Trenton	4,360	7,636
Tweed	200	1,181
Warkworth	74	P.V.
Wellington	153	948
Westport	93	725
Whitby	1,383	4,236
Williamsburg	95	P.V.
Winchester	298	1,017

THUNDER BAY SYSTEM

60-Cycle

	H.P.	Population
Fort William	14,920	30,317
Nipigon Twp.	187	V.A.
Port Arthur	44,730	23,790

NORTHERN ONTARIO PROPERTIES

Nipissing District

60-Cycle

	H.P.	Population
North Bay	4,229	16,013

Patricia District

60-Cycle

Sioux Lookout	315	1,967

Sudbury District

60-Cycle

Capreol	236	1,660
Sudbury	7,852	32,731

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The BULLETIN

The Hydro-Electric Power Commission of Ontario

Volume XXIX APRIL, 1942 Number 4

Falls on Stoney Creek.

MAY 16 1942

Municipal Loads, March, 1942

NIAGARA SYSTEM
25-Cycle

	H.P.	Population
Acton	1,434	1,903
Agincourt	181	P.V.
Ailsa Craig	96	487
Alvinston	97	649
Amherstburg	989	2,704
Ancaster Twp.	345	V.A.
Arkona	54	403
Aurora	1,230	2,821
Aylmer	810	1,985
Ayr	182	760
Baden	525	P.V.
Beachville	699	P.V.
Beamsville	372	1,227
Belle River	164	836
Blenheim	491	1,873
Blyth	107	662
Bolton	155	629
Bothwell	130	683
Brampton	2,726	5,702
Brantford	20,114	30,947
Brantford Twp.	946	V.A.
Bridgeport	117	P.V.
Brigden	84	P.V.
Brussels	136	784
Burford	182	P.V.
Burgessville	38	P.V.
Caledonia	392	1,430
Campbellville	34	P.V.
Cayuga	128	700
Chatham	6,879	17,148
Chippawa	322	1,228
Clifford	90	491
Clinton	608	1,879
Comber	121	P.V.
Cottam	79	P.V.
Courtright	49	355
Dashwood	86	P.V.
Delaware	58	P.V.
Delhi	654	2,430
Dorchester	90	P.V.
Drayton	108	528
Dresden	375	1,525
Drumbo	82	P.V.
Dublin	30	P.V.
Dundas	2,873	5,001
Dunnville	1,372	3,916
Dutton	251	830
Elmira	941	2,069
Elora	427	1,185
Embro	120	420
Erieau	70	281
Erie Beach	9	21
Essex	533	1,886
Etobicoke Twp.	7,307	V.A.
Exeter	522	1,654
Fergus	1,269	2,759

	H.P.	Population
Fonthill	165	860
Forest	469	1,562
Forest Hill	7,235	12,172
Galt	11,289	14,584
Georgetown	1,776	2,452
Glencoe	209	763
Goderich	1,417	4,674
Granton	68	P.V.
Guelph	11,161	22,500
Hagersville	464	1,347
Harriston	364	1,292
Harrow	453	1,092
Hensall	173	686
Hespeler	2,853	2,938
Highgate	84	322
Humberstone	524	2,831
Ingersoll	3,078	5,186
Jarvis	194	513
Kingsville	643	2,453
Kitchener	27,780	33,281
Lambeth	117	P.V.
LaSalle	207	907
Leamington	1,563	6,048
Listowel	1,361	2,984
London	40,222	75,176
London Twp.	502	V.A.
Long Branch	1,066	4,258
Lucan	172	643
Lynden	120	P.V.
Markham	299	1,175
Merlin	90	P.V.
Merritton	8,805	2,916
Milton	1,045	1,915
Milverton	321	994
Mimico	2,440	7,713
Mitchell	624	1,670
Moorefield	44	P.V.
Mount Brydges	100	P.V.
Newbury	32	288
New Hamburg	563	1,441
Newmarket	1,583	3,800
New Toronto	11,640	7,514
Niagara Falls	10,550	18,770
Niagara-on-the-Lake	700	1,764
Norwich	373	1,301
Oil Springs	190	541
Otterville	81	P.V.
Palmerston	564	1,400
Paris	2,111	4,604
Parkhill	164	1,029
Petrolia	1,203	2,768
Plattsville	116	P.V.
Point Edward	1,688	1,199
Port Colborne	1,978	6,772
Port Credit	791	1,934
Port Dalhousie	851	1,599
Port Dover	385	1,790

	H.P.	Population
Port Rowan	99	700
Port Stanley	294	824
Preston	4,152	6,337
Princeton	114	P.V.
Queenston	111	P.V.
Richmond Hill	417	1,295
Ridgetown	523	1,986
Riverside	1,115	5,235
Rockwood	104	P.V.
Rodney	159	758
St. Clair Beach	73	138
St. George	139	P.V.
St. Jacobs	289	P.V.
St. Marys	1,352	4,009
St. Thomas	8,048	16,461
Sarnia	10,985	17,979
Scarborough Twp.	4,167	V.A.
Seaforth	609	1,782
Simcoe	2,464	6,340
Smithville	149	P.V.
Springfield	62	382
Stamford Twp.	2,372	8,275
Stouffville	226	1,198
Stratford	6,878	17,163
Strathroy	1,368	2,834
Streetsville	176	701
Sutton	158	949
Swansea	3,324	6,606
Tavistock	578	1,080
Tecumseh	279	2,331
Thamesford	181	P.V.
Thamesville	214	816
Thedford	76	598
Thorndale	65	P.V.
Thorold	2,433	5,080
Tilbury	1,193	1,923
Tillsonburg	1,417	4,602
Toronto	358,626	648,098
Toronto Twp.	2,351	V.A.
Wallaceburg	3,247	4,802
Wardsville	31	221
Waterdown	201	867
Waterford	507	1,294
Waterloo	5,223	8,690
Watford	327	1,023
Welland	12,676	11,568
Wellesley	105	P.V.
West Lorne	251	768
Weston	4,130	5,784
Wheatley	180	761
Windsor	49,220	103,571
Woodbridge	622	946
Woodstock	8,189	11,584
Wyoming	74	538
York Twp.	18,904	77,175
York E. Twp.	7,545	38,316
York N. Twp.	8,443	V.A.
Zurich	94	P.V.

THE BULLETIN

Published by

THE HYDRO-ELECTRIC POWER COMMISSION of Ontario

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In the Public Service

By C. R. Young, Dean of the Faculty of Applied Science and Engineering, University of Toronto, and President of the Engineering Institute of Canada

IT must be admitted that the service of the public has been prejudicially affected by attitudes such as that succinctly expressed by the Dutch in the observation that "who serves the public serves a fickle master". To my knowledge young men entering the profession of engineering have not infrequently been advised by persons of narrow outlook to avoid municipal work or, indeed, not to enter public service at all. Before them has been conjured up the spectre of low salaries, slow promotion, long continued mistreatment by politicians, to which the servant cannot safely reply, and then, to cap the dismal tale, he is pictured as being metaphorically cast into the street, penniless and disillusioned.

Even Emerson, that embodiment of sweetness and light, was not entirely able to overlook the briars that clustered about the rose. Said he:

"When I have attempted to join myself to others by services, it proved an intellectual trick—no more. They eat your service like apples and leave you out. But love them and they feel you, and delight in you all the time".

The unexpected evidence of realism in Emerson was doubtless prompted by his experience with his neighbour, Thoreau. That delightful, but self-centred hermit philosopher spent his days in idleness and reflection at Walden Pond, a mile or so from the home of the Emersons. With an ear carefully attuned to the welcome sound of the dinner horn of his more prosperous neighbour, there was enough of the one-way quality in their relationship to prompt the allusion to the eaten apples. But I am glad that, despite all this, there is still held out to the benefactor the prospect of some small measure of appreciation.

So, on a background tinted by the critical observations of some disillus-

Address at the banquet of the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities, at Toronto, February 10, 1942.

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Vol. XXIX No. 4

APRIL, 1942

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

ioned persons, may I attempt to sketch the circumstances, qualities and compensations of the public service.

I do not suppose there has ever been a time in which we might more profitably explore the characteristics of the public service and of the effective public servant. In the midst of this war we are confronted with the necessity of far-reaching and drastic controls, administered by officials of the Government. We are, of necessity, regimented. It is one of the inescapable costs of waging a successful war, of which we shall not be entirely free for some years after the conflict is over. The number of persons engaged in the public service is likely to increase rather than diminish and it is therefore of importance for us to know something of the conditions of that service and of the personal qualities essential for success in it.

Not unlikely many of you will say that the truth respecting the public service can come only from those who have served long in public capacities under the political conditions that ordinarily exist in democratic countries. That may be true, but nevertheless, as one who has passed many years at a comparatively quiet observation post that overlooks a small sector of the public service front, I wish, with diffidence, to hazard some tentative views on the subject. This is done somewhat in the spirit that actuated the brilliant and versatile Dr. Mahaffy, at one time Provost of Trinity College, Dublin, who when asked if he was a clergyman replied, "Yes, but only a little, and not in any offensive sense".

It will be conceded, I am sure, that success in the public service will be contingent upon the existence of certain favourable factors, without which little can be expected.

It is axiomatic that one who would serve the people well must have a solid and abiding faith in democracy as a system. He must feel that the public is worth serving and that the mechanisms of democratic government will render that service possible. He must possess a warm desire to see his fellow

citizens progress in the art of self-government. Criticism and belittling of the institutions through which democracy must work will get us nowhere. I do not think that the observation of Major-General George W. Goethals with respect to deliberative bodies is of much help to us. It was his view that "all boards are long, narrow and wooden".

Nor do I think that however exasperating the aberrations and shortcomings of the party system may be to a person of independent mind, there is any helpful service in undue derision of it. Morris Llewellyn Cooke was not far wrong in his remark that "There is no finer service which the friends of good government can render than that of being discriminating in their comments in the influence of party politics on government".

It is unnecessary, of course, to point out to you gentlemen who carry out the duties of trustees for the consumers of electrical energy in this province, that an essential of success in the public service is a regard for the public interest. Democracy means more than freedom to speak, write, worship, or vote as you please. It means more than the absence of absolute government or tyranny of a hereditary caste or dictatorship. It involves the principle of partnership in government and, as partners, a necessary contribution to insure the common success. It is a bilateral contract, not a one-way commitment. It does not grant licence to do precisely as we wish without regard to the public welfare, but involves a duty to safeguard, protect, and defend our institutions as well as our lives.

In carrying on the public business the sole consideration should be the creation of those conditions and facilities that can best contribute to the public welfare and happiness. Unfortunately, narrow views, not unmixed with selfishness and jealousy, are recorded of some public bodies. Robert Ridgway, the celebrated American engineer, in speaking of the development of rapid transit in New York City, records that for a long time something approaching a feud existed between the state-appointed Transit Commission and the city-appointed Board of Estimate and Apportionment, largely due to Mayor Hylan's uncompromising attitude to the state body. Anything that was proposed by the Commission was rejected or ignored by the Board. Says Ridgway:

"There is a kind of political human nature that makes them act that way. Both wanted good rapid transit but did not want the other fellow to accomplish it".

For success in the public service, brilliancy of mind is less esential than solid capacity linked with dependability. It is very difficult to utilize geniuses and prima donnas in the public service. Public funds can scarcely be set aside for the provision of nursemaids for them.

Undue weighting on the side of brilliancy of mind has its dangers. I cannot recommend to you the basis of decision of the scientist, Ronald Ross, who when looking for an assistant to help him in his search for the malaria microbe in India, hired a man who had the appearance of a scoundrel, on the ground that scoundrels are much more likely to be intelligent.

Nor, on the other hand, could I advocate the basis of selection reported of Lord Ellenborough, the great jurist, who removed his account from his banker, Samuel Rogers who wrote poetry, and declared his intention of seeking out the stupidest man in the field of banking as the safest to be entrusted with the custody of his funds.

The fact is, the work of the world must be done by that great army of persons with average ability, of good will, high moral standards and strict dependability. It is the common or every day man that makes the wheels of the world go round. Without him we should very soon come to a full stop.

High up in the list of essential qualities for success in the public service is a sense of responsibility. No better example of this characteristic in public men exists than is to be found in those who make a career of public life in Britain. The standard is high and those who depart from it are, irrespective of rank or position, speedily retired into oblivion. So keenly did Dr. Arnold, of Rugby, feel the importance of this characteristic that he was prompted to observe:

"There is no earthly thing more mean and despicable in my mind than an English gentleman destitute of all sense of his responsibilities and opportunities, and only revelling in the luxuries of our high civilization, and thinking himself a great person".

Absence of a willingness to assume responsibility and take whatever risks may be involved has been the undoing of both men and nations. No greater condemnation of the lack of it has been voiced than that by Emile Faguet. He admits that the passionate desire of a Frenchman is for a profession of complete repose, that is, one that involves no risk and no responsibility. An official, according to the French idea, is a man whose first and almost only duty is to have no will of his own. The functionary is a cog in the machine; no one asks of him initiative, or zeal, or strenuous labour; that would throw everything out of gear, impede the general motion, disturb the established order. To work infinitely little, never to think for himself, but to present himself for adjustment to the machine at the very minute the machine needs him—that is all that is asked of him. For any nation whose citizens place such an extraordinary interpretation upon their national obligations, disaster cannot lie far ahead.

It goes without saying that one who is to serve the public interest well must possess that degree of firmness requisite for strict performance of his duty, not to speak of his own peace of mind. Those public officials who have enjoyed the longest tenure of office and the highest degree of success have been men who could not be diverted from a strict and impartial performance of their duty by representations either from above or below.

No end of trouble and stagnation has arisen in the public service through the desire of timid-minded officials to be distinguished for their consistency. You will recall Emerson's characterization of consistency as "the bugbear of little minds". We should do well, too, to remember in this connection the remark of Lord Morley, in a memorable speech, who when accused of inconsistency with his past utterances, stated

that he would not take up the time of Parliament for even ten minutes to justify his own character for consistency.

Little progress can be expected without imagination let run within reasonable bounds. Unfortunately, fear of criticism has prevented many a public official, otherwise of high qualifications, from advocating proposals that if carried into action would have brought much advantage to the government that he served.

I am reminded of the devastating reproof for lack of courageous advocacy administered by one of the Toronto newspapers to a contemporary some years ago, to the effect that the only constructive proposal made by it in forty years was that when a citizen ate nuts he should collect the shells and put them in an empty cocoa tin which the baby could then use as a rattle.

Determination to study and investigate is an essential of long-range efficiency in the service. There must be forward looking. However excellent the existing system may be, no one can represent it as perfect, and a public servant who expects to make his most effective contribution should look beyond and through the system and procedures gathering about it to discover if by chance there may not be some better way. Indolent acceptance of what is obviously not in the public interest means to the public servant swift and certain deterioration.

One may well take to heart the counsel of Jean Paul Richter, who observed that if we had for hours been standing on the bank of a river pulling out drowning wretches who were swept along in the flood, it would be well to go upstream and find out who was pushing them in.

One of the difficulties that has militated against the entry of many well-qualified persons into the public service has been the lack of public recognition. Unfortunately, there is altogether too much disposition on the part of a certain type of politician to belabour the public servant in the hope of creating for himself a reputation as a guardian of the interests of the people, no matter what injustice may be done to the one attacked. For such tactics I have the utmost contempt.

Nothing would more rapidly build up a strong and devoted body of men and women in the public service than the adoption by common consent of the practice of honouring in some definite and conspicuous manner those who become distinguished in it. For wrongdoing on the part of those occupying posts of trust there should be nothing but condemnation, but for those who labour long and faithfully in promoting the public welfare there should be generous public appreciation of services well performed.

If it became generally known that positions in the public service were to be regarded and acknowledged as, *ipso facto,* high evidence of trust reposed, and the accompanying marks of appreciation and honour were generous enough, we might well create in this country something analagous to the highly-regarded civil service of Great Britain.

Rightly treated, the service of the public should become a source of high personal satisfaction and a field of commendable emulation. The greatest of

our citizens have not been unwilling for many laborious years to devote to the public cause their fullest energies and solicitude.

In his memorable address to the United States Congress, Winston Churchill stated his own position in these words:

"I owe my advancement entirely to the House of Commons, whose servant I am. In my country, as in yours, public men are proud to be the servants of the State, and would be ashamed to be its masters".

In the history of the English-speaking world may be found innumerable instances of men who have brought distinction and honour to their country and to themselves from devoted service. Few men have so greatly influenced the course of English history as did John Hampden. Of him Macaulay said:

"The celebrated Puritan leader is an almost solitary instance of a great man who neither sought nor shunned greatness, who found glory only because glory lay in the plain path of duty. During more than forty years he was known to his country neighbours as a gentleman of cultivated mind, of high principles, of polished address, happy in his family, and active in the discharge of local duties; and to political men as an honest, industrious and sensible member of Parliament, not eager to display his talents, staunch to his party, and attentive to the interests of his constituents".

If there should remain any need for benediction on the labours of those who toil in the public interest, I give you a citation which some months ago was sent to me by an old friend on a sheet of paper, containing nothing but the reference "Matthew 23:11". Says the Master of all teachers:

"But he that is greatest among you shall be your servant."

In a lecture to the Institution of Civil Engineers at London, England, on November 4, 1941, as reported in *Engineering*, Professor C. E. Inglis, speaking on University Education of Engineers, closes with the following extract, the authorship of which he had been unable to discover:

"Give me a good digestion, Lord, and
also something to digest;
Give me a healthy body, Lord, with
sense to keep it at its best;
Give me a mind that is not bored, that
does not whimper, whine or sigh;
Don't let me trouble overmuch about
that fussy thing called 'I';
Give me a sense of humour, Lord, give
me the grace to see a joke;
To get some happiness from life, and
pass it on to other folk."

The Lighting of the Future

By F. G. Reed, Illuminating Engineer, H.E.P.C. of Ontario

THIS subject, in the very nature of things, requires us to step from the known to the unknown. As the established facts of science carry us no farther than the immediate present it will be necessary to add to these some philosophical reasoning. Thus it is apparent that any conclusion is likely to be unstable. But it is worthwhile, nevertheless, to consider the future and try to be mentally equipped and prepared to make the most of it.

Fortunately for the sake of this discussion we do know the trends along which existing light sources seem to be developing, and we also know what some of our future needs may be; and these two known quantities may lead to some very fair appraisals of the future of lighting. So, as a pattern upon which to develop the subject, suppose we state the fundamental premise this way:

The Lighting of the Future will depend upon two things:

(1) The development of existing sources and the discovery of new ones.

(2) The *needs* of the future as seen in the fields of
Lighting for Seeing
Lighting for Atmosphere.

Light Sources

Development of Existing Sources

The thought of improving known sources at once suggests improvements in efficiencies. The passing years of research see old records shattered, new ones made. In 1905 we got 4 lumens per watt; in 1920, 18 lumens; and in 1941, 75 (100 in the laboratory). That is about 12 per cent of impressed energy radiated in the visible part of the spectrum. With luck and good management I wonder when we may reach the ultimate goal of 220 lumens per watt? That is the theoretical maximum if all of the impressed energy were to be radiated as white light. Or when shall we attain to 620 lumens per watt, which is the theoretical maximum if all of the energy were to be radiated in a line spectrum at the wave length 5560 Angstroms, the peak of eye sensitivity? Of course no source can be developed to that point, but we shall consider a few of them to see what is being accomplished and what is likely to be accomplished.

The first is the incandescent solid, and it already has a ceiling of 91.4 lumens per watt. This is not merely a practical ceiling depending upon vaporization temperatures, etc., but a theoretical one beyond which it will be impossible to go. The 1000 watt projector lamp now gives us 37 lumens per watt. In the gaseous discharge field we have various efficiencies leading off with a high pressure mercury arc at 65, followed by a number of low voltage fluorescent sources varying from 75 to 40 odd.

The phenomenon of fluorescence has been a laboratory toy for a hundred years. We were long aware of several materials that would fluoresce under

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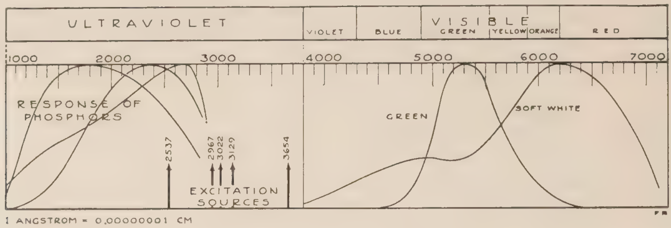

Fig. 1.—Illustrating comparison between frequencies of excitation sources and sensitivity peaks of fluorescent compounds.

certain kinds of excitation, but we didn't have fluorescent lighting until very recently. The secret of success was apparently the development of a suitable exciting source. Then, having a new energizer that really brought results, the fluorescent materials themselves suddenly came in for important attention. Thus we have now at least two fields of investigation—the fluorescent compounds and the sources that activate them. Any important data uncovered in the one field will likely have a startling effect on research in the others.

As an illustration, take this 2537 A. mercury line (Fig. 1) which is at present responsible for most of the fluorescent effect. This line does not necessarily occur at the peak of sensitivity of the compound which it activates. Calcium tungstate and zinc silicate, for instance, have sensitivity peaks at 1800, 2300, and 2700 A.; and they show responses all the way from 1000 up to 3100 A. Other substances have other peaks. The reason we use the 2537 A. line is because a certain low pressure mercury source has been found that gives an abundance of energy at that resonance wave length. Present combinations are yielding efficiencies as high as 75 lumens per watt green, or around 50 in a modified white.

These facts are not new to you, but they are springboards for new ideas. Now is it not reasonable to suppose that other excitation sources will be found that can be made to yield large quantities of energy corresponding much more closely in frequency to the sensitivities of known compounds; and conversely, that new phosphors will be compounded that will be extremely selective in the desired bands, and producing radiation of a desirable spectral quality? Of course, there are other factors too.

I have great confidence in the physicists even though they do tell us that most of their researches bring negative results. We have their own admission that luck is a big element in research, and so it is. We have a creditable and costly achievement today and we think we have arrived. Tomorrow the whole thing may be made obsolete by an unexpected discovery. Thus important developments seem inevitable.

This does not suggest that the fluorescent lamp is not a creditable and extremely useful development. Indeed it is causing something of a revolution in lighting practice. But I do suggest

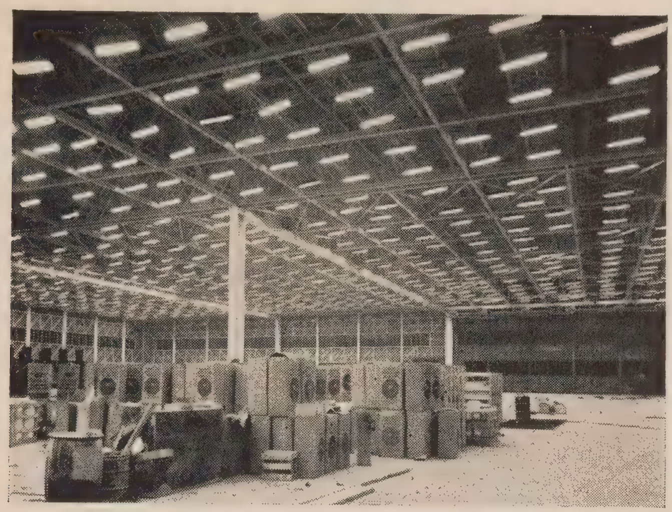

Fig. 2.—An aircraft plant lighted by means of 2-lamp RF fluorescent units. Lighting is good but maintenance costly.

that its merit is relative, and that the fluorescent lamp we know today is subject to the same *vast* improvements that the filament lamp experienced.

A source that appeals to me as having great possibilities is the high voltage fluorescent tube. That prediction is made while assuming that whoever manufactures the equipment will learn how to do it properly and assure high efficiencies. As it is developed it will probably offer serious competition to the standard low voltage type of utilitarian lighting.

For instance, take the ultra-modern job illustrated in Fig. 2—about 2000 low brightness spots at $20.00 to $30.00 a spot, and a full-time maintenance staff required; Why not run those spots together, not by adding more sections of the same, but by making the light source continuous. Use reflectors or transmitting media, which may be sectionalized. Give the lamps a rated life of at least 5000 hours, maybe 10,-000. The cost, on a production basis, may come as low as $2.00 a foot in this type of installation. This, I think, will be a contribution to the lighting of the future. It is here in embryo even now, see Fig. 3.

Laboratory tests indicate that when properly designed, this will give us efficiencies at least equal to the low voltage fluorescent[1]. Some indoor installations have been in use for thousands of hours with no service calls to date. Manufacturers of the equipment tell me that the present cost, not on a production basis, is around $4.00 per foot, including a reflector. In England it had reached a fair state of development before the war.

High fluorescent lighting presents problems that are both technical and commercial. In its design the relation-

Fig. 3.—Illustrating application of high-voltage fluorescent tubing for utilitarian lighting. Higher efficiencies and simpler methods of fabrication will come.

ship of current, voltage, tube diameter, gas pressure, and transformer loading must be carefully worked out for each installation, depending upon its character. Its use, therefore, requires skill and special technique.

The fact that the fabrication is not in short easily-handled units makes it an unattractive proposition for the manufacturer with a wide territorial set-up. That is why the sign tubing man may be handling most of the applications in this field for some time to come. He will have to be brought into the illuminating engineering association and taught how to accurately control the various elements of the product. Eventually a way may be found to package the equipment, and sooner or later the legitimate lighting equipment manufacture will find a way to handle it profitably and to public benefit.

There are doubtless other sources that deserve to be considered along with this one I have mentioned. I chose this in particular because it seems to be near the hatching point.

New Sources

The matter of new sources, apart from the ones we already know, will have to be left to our imagination. Their discovery is certain, if unpredictable, because such discoveries are usually the by-product of other research. I dare say some men could tell us a few secrets if they would; but we shall have to wait, meanwhile perfecting the ones we have and constantly improving our lighting practice.

This disposes of the first part of the subject; namely, "The Lighting of the Future will depend upon the development of existing sources and the discovery of new ones".

The Needs of the Future

We shall now examine the future from another angle. This perspective we shall call, "The Needs of the Future as seen in the fields of Lighting for Seeing and Lighting for Atmosphere".

Lighting for Seeing

Lighting for Seeing is *lighting for human efficiency* and *wellbeing*. This is that lighting which contributes to doing the best work, in the shortest time, with the greatest ease, and with a maximum of reserve after the work is accomplished. Something more than productive efficiency is implied here: the "plus" that contributes to human well-being after the peak of production has been reached. This is lighting for both work and play, wherever hand and eye are co-ordinated, or wherever the eye is used alone.

In this department we don't have to guess at the needs of the future: they are the needs of today. Extensive research has yielded abundant data on the processes of seeing and the great mass of related physiological and psychological factors. From these we know the requirements of good lighting; but while we have approached, we have so far not attained.

It has been widely contended, with no particular argument to the contrary, that man does best under Nature's lighting. As Nature's lighting was designed for the benefit of man and other creatures, we may assume the argument to be sound. A disparity of opinion seems to exist, however, as to how this lighting may be best simulated indoors. The latest treatise I have read seems to indicate that "comfortable lighting" is not merely a matter of duplicating outdoor lighting as of any hour of the day, but of adhering to the *brightness ratios* that obtain under satisfactory outdoor conditions. The effects of brightness contrasts on visibility have long been tabulated, particularly by a certain Dr. Nutting in 1916. His figures are still good.

Investigation of Nature's lighting reveals two important aspects of its comfort: first, the illumination on a vertical plane at the eyes does not as a rule exceed 20 or 25 per cent of that on the object of regard; second, the contrast of *average* brightness seldom exceeds 10 to 1[2].

Fig. 4a illustrates the first point. On a clear day, with the sun at an angle of 45° behind the observer, light on the work is about 5500 footcandles—3500 contributed by direct sunlight, 2000 by the whole sky dome. Half the sky dome contributes only about 1000 footcandles on a vertical plane at the eye. The lighting is comfortable.

With an overcast sky (Fig. 4b) the lighting is not comfortable to anyone not wearing a hat or an eye shade. In this case the sky dome may contribute 2000 footcandles to the work, while half the dome is responsible for 1000 at the eye. The ratio is 1 to 2 instead of 1 to 4. This is comparable to totally indirect lighting in a large interior.

As a satisfactory method of lighting, the indirect "breaks down" at about 50 footcandles because of extreme ceiling brightness[3]. At lower levels the contrasts are not obviously objectionable; but beyond that level (and we *must* go beyond it for maximum returns in human well-being)[4] we shall have to apply

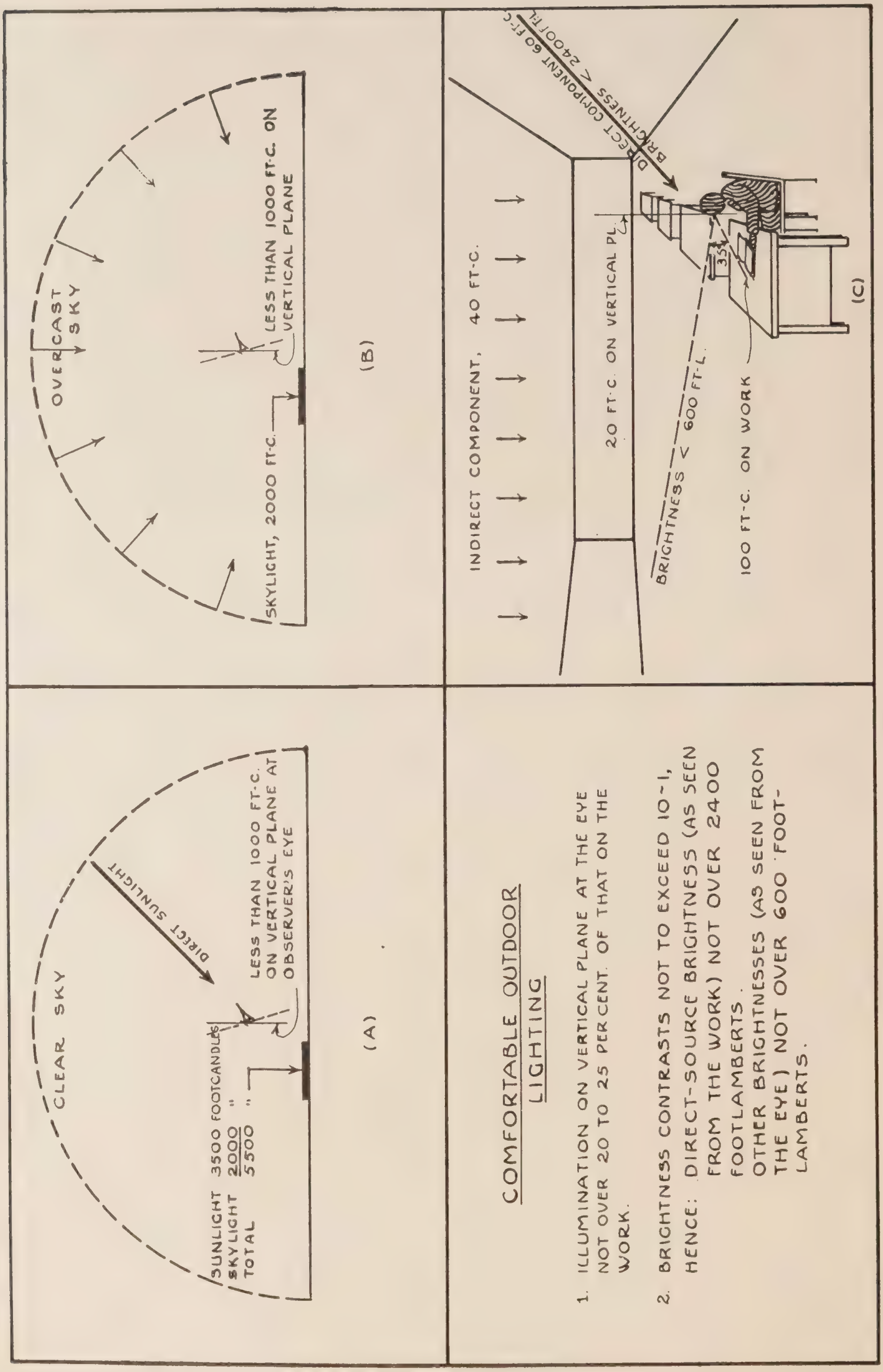
CLEAR SKY
DIRECT SUNLIGHT
SUNLIGHT 3500 FOOTCANDLES
SKYLIGHT 2000 "
TOTAL 5500 "
LESS THAN 1000 FT-C. ON VERTICAL PLANE AT OBSERVER'S EYE
(A)
OVERCAST SKY
SKYLIGHT, 2000 FT-C.
LESS THAN 1000 FT-C. ON VERTICAL PLANE
(B)
COMFORTABLE OUTDOOR LIGHTING
1. ILLUMINATION ON VERTICAL PLANE AT THE EYE NOT OVER 20 TO 25 PER CENT. OF THAT ON THE WORK.
2. BRIGHTNESS CONTRASTS NOT TO EXCEED 10-1,
HENCE: DIRECT-SOURCE BRIGHTNESS (AS SEEN FROM THE WORK) NOT OVER 2400 FOOTLAMBERTS.
OTHER BRIGHTNESSES (AS SEEN FROM THE EYE) NOT OVER 600 FOOT-LAMBERTS.
DIRECT COMPONENT 60 FT-C.
BRIGHTNESS < 2400 FT-L
INDIRECT COMPONENT, 40 FT-C.
20 FT-C. ON VERTICAL PL.
35°
BRIGHTNESS < 600 FT-L.
100 FT-C. ON WORK
(C)

FIG. 4

Fig. 5(a).—Ceiling as seen from "work eye view".

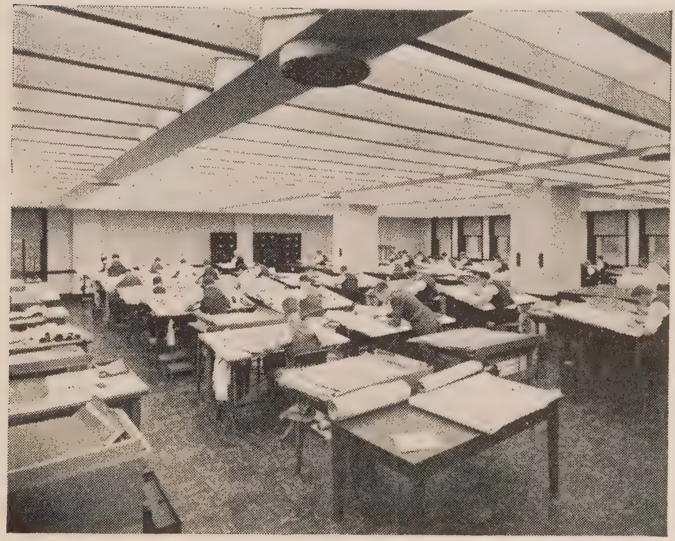

Fig. 5(b).—Ceiling as seen from draughtsman's point of view.

Directional lighting by luminous ceiling in draughting room.

somehow the ratios of illumination and brightness found in nature.

Suppose we attempt to apply these ratios in designing for 100 footcandles in a large room (Fig. 4c). Let us first supply a direct component giving 60 footcandles and an indirect one giving 40. There are the 100 footcandles, and since half the ceiling will contribute something less than 20 at the eye, the illumination ratio is satisfactory. There remains the factor of brightness contrast or glare, both direct and reflected. We dare not use a source indoors analogous to the sun because of the many specular reflections. (In nature these are not encountered except in the cases of sand and water). Therefore, the direct source must be of low brightness. By observation it has been determined that in offices lighted to 50 footcandles the brightness of a source as seen from a "work's eye view" may not exceed 2000 footlamberts, and that of areas or sources seen directly, within 35° of the line of vision, may not exceed 500 footlamberts. Dr. Nutting said that to double the illumination would permit adding only 20 per cent to the brightness; so for our purpose we must maintain the direct source brightness at 2400 footlamberts and all brightness in the field of view at 600 footlamberts.

This will be the lighting practice of the future—a direct component combined with general "dome" lighting, and with ratios of illumination and brightness maintained within specific limits. There is one installation of the present day that conforms in nearly, if not all points to these specifications; that is the draughting room of the Commonwealth Edison Co., Chicago (Figs. 5a and 5b). In this case the direct component and the ceiling dome component are one and the same thing; but it is not comparable to a totally indirect system because the lighting is definitely directional, and the light originates behind the worker to be reflected away from him. If you subscribe to Lighting Data Sheets, you will be familiar with the mechanical details of this installation. The future will doubtless see other, and possibly cheaper, solutions of this problem.

APPRAISAL OF VARIOUS LIGHTING SYSTEMS

Rank	Lighting System	Foot-candles Horizontal Plane	Ratio of Foot-candles on Verticle Plane to those on Horizontal Plane
1	Troffers	100	0.27
2	Troffers	50	0.27
3	Indirect	25	0.60
4	Indirect	50	0.62
5	Enclosing Globe	25	0.74

Fig. 6

Fig. 6 is a list of various lighting systems judged by the criteria we have mentioned. It is interesting to note that a 25 footcandle indirect system ranks slightly higher than a 50 footcandle one. It is a fairly safe assumption that the Commonwealth Edison installation would rank higher than any of these—alternate stripes of light and dark, as seen in a troffer system, are not found in nature.

A sub-heading under Lighting for Seeing is "Lighting for Selling". In

Fig. 7.—Accent lighting by concealed spotlight in general lighting fixture.

this case, to see quickly and well is the immediate object; but ultimately the object is to persuade the observer to action. Lighting in this field in the past decade has been noted principally for increasing levels due, for the most part, to consumer-research studies. Carefully controlled experiments yielded definite data on the "attention getting" power of light; and these data led to the general acceptance of higher levels.

It is doubtful that this will continue indefinitely, even considered apart from the effects of the war. Once the *general lighting* level in a store has been raised to 30 or 40 footcandles, there is little evidence to show that more business will result merely from higher levels of general illumination. From that point onward it is a matter of skilful use of *accent* lighting—presenting for attention, by means of local lighting, some particular merchandise that is offered for sale.

The methods by which such special lighting is achieved will depend a good deal upon the ingenuity of the lighting equipment manufacturer. It may be that trick methods of concealing the

sources will be sought. Fig. 7 illustrates one solution of the problem.

Atmospheric effect will gain more and more attention in store lighting, as it will in many other applications[5]. That thought leads to the next division in Needs of the Future, "Lighting for Atmosphere"—in any type of interior.

Lighting for Atmosphere

This is *lighting to induce feeling.* It is lighting to control emotions, not necessarily with the intent of leading to definite action. It induces mental and spiritual attitudes according to the plan of the designer. For instance, lighting may be used as a stimulus to admiration, surprise, enthusiasm, excitement; or it may contribute to relaxation, confidence, peacefulness, or study. Decorative lighting is included in this as a sub-heading, but atmosphere and feeling are controlled as well by properly designed general illumination. This is what we will call "atmospheric lighting".

Of all types of lighting, that for atmosphere has received less attention from the illuminating engineer than have the others. Perhaps this is because its application is less an exact science than is that of the others: its quantities are less subject to analysis and direct measurement; its application is by "feel"; its formulae are empirical.

Now possibly we only *think* that atmospheric lighting is unscientific. Engineers sometimes disparage the architect because his profession is not an exact science. How do we know it is not? How do we know but that beauty in the arrangement of anything is a matter of exact mathematical relationships which we have not so far learned to analyse and apply? We have a sense of appreciation of beauty, more developed in some than in others. This sense of appreciation may be a mathematical response to a mathematical stimulus. If we understood its laws we might design for atmosphere in the same precise manner in which we now design for luminous efficiency.

As it is, a skilful designer applies with the aid of an endowed and developed sense what might be applied by exact science. It would therefore be well if engineers would cultivate to some extent that sense of design. We should learn to appreciate what the architect is trying to do, and our technical contribution would help him to do it better.

Only recently have architects begun to embrace the science of illumination and to realize that, so far from being a mere utility, it is an important element of aesthetic design. Whenever an architect seriously undertakes to learn the characteristics of light, its physiological and psychological effects, and the physical characteristics and limitations of lighting equipment, he applies it with intelligence and with gratifying results. And illuminating engineers —whenever they, for their part, have realized the atmospheric possibilities of light, where they have made a serious attempt at architectural appreciation, they too have applied it with intelligence and gratifying results.

The ideal is complete co-operation of designer and lighting engineer, the designer indicating the atmospheric requirements of the space and perhaps even sketching in broadly the method of lighting treatment, while the engineer, with a very sympathetic under-

Atmospheric lighting; top left—jewelry store; top right—bank; lower—lounge bar.

standing of the architect's mind and purpose, fills in the picture with the deft strokes of a technical expert.

CONCLUSION

In every field of lighting application the important improvement to be expected is that lighting equipment will become an integral part of building design and structure. This is an obvious conclusion as regards large-area sources, for they certainly do not lend themselves easily to the accepted idea of suspended fixtures. They look clumsy and they are clumsy. Both direct and indirect lighting will be accomplished by means of "built-in" equipment.

We are fully aware of the shortcomings of such custom-made lighting as against the ready-made equipment. The ready-made is expertly designed, and even in the hands of the inexpert will serve the cause of good lighting. Custom-made, on the other hand, is subject to inexpert bungling. The finest dream on a draughting board may turn out to be something of a nightmare when the lighting equipment is finally installed. Some designers expect all the physical elements of the scheme simply to fall into place of their own accord and at the behest of the lowest bidder! Such elements as intensity, brightness,

Atmospheric lighting in a clothing store.

mechanical excellence, ease of installation, and maintenance are not matters that may be left to chance.

In spite of these problems the future will see high-class custom-built work; and it will arrive when the architect learns more about lighting and the engineer comes to have a greater architectural appreciation. The lighting of the future will demand the services of an expert—not the self-styled expert, not the novice, but an expert who comes to be recognized as such in his own profession as well as the profession and public he serves.

The opportunist will always be with us to prey upon the uninformed; but the big money will go to the commercial enterprise whose policy is that of the long-range view, whose engineers are intellectually equipped to take up advanced knowledge, embody it in better practice, and sell it at a profit to all.

REFERENCES

[1]Marden and Meister, Illuminating Engineering, 1941-10.

[2]"Comfortable Lighting", Harrison and Luckiesh, Illuminating Engineering, 1941-10.

[3]"What Is Wrong with Our 50-Footcandle Installations?" Ward Harrison, Transactions of the I.E.S., 1937-2.

[4]Luckiesh and Moss, "The Science of Seeing" p. 273.

[5]"Brightness Patterns", by W. M. Potter, The Magazine of Light (G.E.) 1941-7.

Indirect Fluorescent Lighting

After 500 hours of use this luminous indirect fluorescent lighting system gives 80 footcandles of glareless shadowless illumination. Equipment is available in Canada for 60 cycle operation only. Photograph courtesy Amalgamated Electric Corporation, Limited, Toronto.

Peak Voltage Variations Amplified and Observed

By J. H. Waghorne, H.E.P.C. Laboratories

VARIATIONS in the peak value of an a.c. voltage can be detected and observed if the voltage is applied to the control grid of a receiving type triode which has a large d.c. bias and observations made in the plate circuit.

The basic circuit is shown in Fig. 1.

Either the a.c. voltage applied to the tube or the d.c. bias should be controllable. For 110 volts a.c. supply a 90 volt portable B battery used as bias as shown at "B" with a potentiometer to control the a.c. voltage is very satisfactory. No extra plate voltage supply is required as the a.c. voltage to be observed will supply plate voltage of the right polarity at the right time if connected as shown. Any triode tube can be used but one with sharp cut off is to be preferred. Filament current supply is not shown as that depends on the tube used.

Operation of the circuit can be followed by means of Fig. 2. The sum of the d.c. bias voltage and the a.c. voltage applied to the control grid will hold the grid below the cut-off point for most of the a.c. cycle. However by adjusting the amplitude of the a.c. voltage the positive peaks can be made to rise above the cut-off point and the tube will conduct. The plate current then consists of a series of unidirectional pulses varying in magnitude with the peak value of the a.c. voltage.

If the variations in peak voltage are slow enough for a meter to follow they can be observed on a milliammeter placed in the plate circuit. (The range of the milliammeter will depend on the tube used.) However, if a cathode ray oscilloscope is available the individual peaks can be observed as shown in the lower half of Fig. 2. The oscilloscope is connected across a resistor in the plate circuit as shown at "R" in Fig. 1. The value of the resistor is not at all critical—2000 ohms would be satisfactory for any tube used.

If an investigation requires observation of both positive and negative peaks

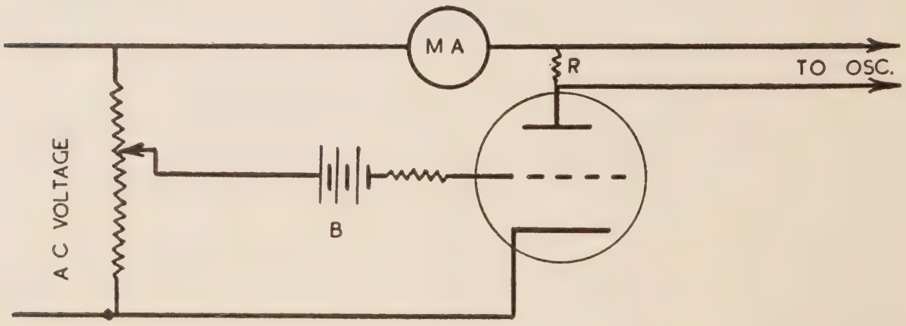

FIG. 1

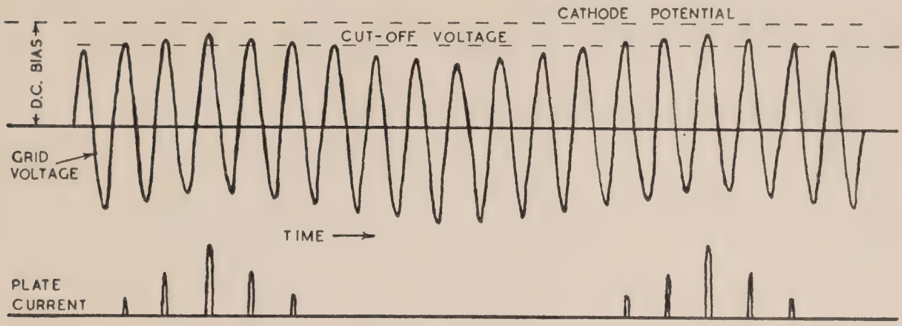

FIG. 2

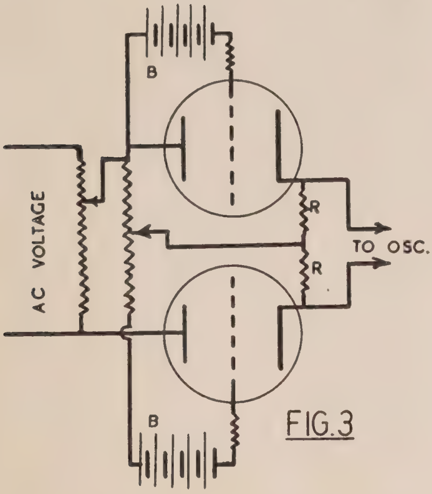

FIG. 3

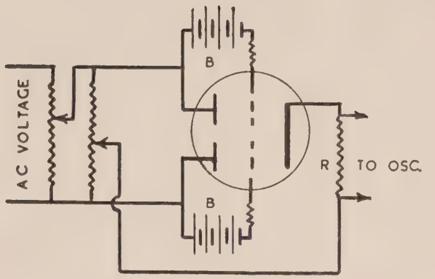

FIG. 4

at the same time this can be done in two ways. In order to show the positive peaks on one side of the oscilloscope base line and the negative peaks on the other the circuit of Fig. 3 can be used. Two similar tubes are used and two bias batteries are required. The load resistors have been shifted to the cathode circuit in order to connect the oscilloscope to both of them. (The negative feed-lock introduced in this manner is not serious as the amplifier on the oscilloscope will give plenty of amplification.) The value of these resistors can be reduced to about 250 ohms. Voltage control to both tubes can be secured as shown by using one potentiometer to control the amplitude of the voltage to both tubes and the other to control the proportion of the voltage applied to the two tubes.

A double triode tube can be used to show both positive and negative peaks at the same time by using the circuit as shown in Fig. 4. The use of a common cathode results in both positive and negative peaks being shown on the same side of the oscilloscope base line. A value for "R" of 250 ohms is satisfactory here also.

Sir W. H. Bragg, O.M., F.R.S.

A RECENT issue of *Engineering* records the death of Sir William Henry Bragg, an outstanding scientist, at London, England, on March 12, 1942. He was a native of Wigton, Cumberland, where he was born on July 2, 1862, and spent his early years on his father's farm. Shortly after graduating from Trinity College, Cambridge in 1884, he was appointed Professor of Physics and Mathematics of the University of Adelaide, Australia, which post he held for 22 years. In 1909 he became Cavendish Professor at the University of Leeds, and six years later went to London as Quain Professor of Physics, retaining this chair until 1923, when he was appointed Director of the Royal Institution, Fullerton Professor of Chemistry and Director of the Davy-Faraday Research Laboratory, positions which he continued to hold until his death.

During the war of 1914-18, he was associated with the Admiralty in connection with experimental work on submarine detection, receiving the C.B.E. in 1917 and the K.B.E. in 1920. The Order of Merit was conferred on him in 1931. He was President of the Royal Society from 1935 to 1940, an Honorary Fellow of Trinity College, Cambridge, and received honorary degrees from no less than sixteen British and American universities. In conjunction with his son, he was a recipient of a Nobel Prize in 1915. He was recipient of a number of medals from societies and universities in Europe and the United States and was a member or corresponding member of the principal scientific societies concerned in his special field of research. He was a particularly valuable member of the Advisory Council for Scientific and Industrial Research, and of various organizations created by the Government to enlist the co-operation of scientists most effectively in the prosecution of the war.

Bragg began his experimental research work at a time when men were keenly interested in the newly found radioactive properties of various heavy elements and in X-radiation, and published his first scientific work in 1904, which has remained a standard reference work of its time. It described the results of an investigation into the ranges and velocities of the heavy, positively-charged alpha-particles from radium and other radioactive substances, on their absorption by gases and solids, and on the ionisation that they cause. From this work he was led to consider the nature of the gamma-rays of radium and of X-rays.

Working with his son, W. L. Bragg, who had just graduated from Cambridge, he now turned his attention to the analysis of crystals by X-rays, from which the ionisation spectrometer came into existence, and at once an immense field of research was opened up. The device developed underlies the present accepted methods of analysis of complicated structures, and in 1915 he and his son were jointly awarded the Nobel Prize for Physics. It is significant that with part of the prize money, he purchased a really first-class lathe.

In 1916 he gave up his X-ray work for a time, to devote himself to problems connected with the war. As Di-

rector of the Admiralty Research Station, he devised a method of submarine detection based on sound location.

After the armistice he returned to his research on crystals. This led to an investigation into the construction of compounds in which the existence of a separate chemical molecule was most likely, namely, the compounds belonging to the immense field of organic chemistry. He was able to show, by a comparison of the crystalline architecture of naphthalene and anthracene, that the molecules of these two substances were almost exactly as the chemist had supposed them to be. Thus the structural formulae of the organic chemist were proved to have a real significance.

From this time onward, a constant stream of experimental and theoretical work was poured forth by the team of research workers whom Sir William had gathered around him at the Davy-Faraday Laboratory, and who were inspired and guided by his genius. The use of photographic methods was supplementing the ionisation method of determining crystal orientation, and was soon to supersede it for general purposes. Such photographic methods were made more useful by the development at the Davy-Faraday Laboratory of various forms of photogoniometers and of intigrating photometers. On the mathematical side, classified criteria were published by means of which the space-group could be determined with a minimum of labour, and later the geometry of the rotation method of crystal analysis, previously rather formidable, was reduced to order and comparative simplicity.

Sir William did little, if any, experimental work after about 1926, except in the form of preparation of lectures, but he excelled in the art of deduction and interpretation. He wrote a number of books, gave many delightful courses of lectures, and wrote many articles describing current research and its applications.

During the last two years of his life he was greatly interested by new phenomina, the observation and photography of which were only made possible by means of very powerful X-ray beams. He had a profound belief that natural laws are not so complicated that they have to be expressed in masses of equations, and was sure that, if the phenomena were properly understood, they could be visualized and expressed quite simply. He died, as he would have wished, in full possession of all his powers, yet leaving no unfinished work behind.

The Development of Mechanisms in Ancient China

By Dr. H. Chatley, M.Inst.C.E.

ONE of the commonest reactions of the older Chinese scholars to the mechanical technique of the West has been the assertion that the Chinese themselves had originated machines in the past and that the principles of the new devices and of physical science in general are all to be found in their ancient literature. Some Western scholars of eminence (for example, Professor H. A. Giles) have partly accepted this broad claim, while others have rejected it altogether. China has been largely cut off, by deserts, mountains or seas of great extent, from the Near Eastern area in which European technique originated, and in this respect it may be compared with Central America. Strangely enough, in both areas there was an outburst of technical development, shortly before the beginning of the Christian era, which may justly be compared with that which occurred almost simultaneously in the West.

One great difficulty in Chinese studies is the unsatisfactory character of the records prior to about 100 B.C. (or even as late as A.D. 25), due to the practice of embodying new or traditional matters in ancient texts without warning. The major technical fact that emerges is the existence in China of wheeled chariots at a date not very different from that at which they first appeared in Egypt. The wheeled cart was very ancient in Babylonia (3000 B.C.), and simple small wheels for a scaling ladder occur in an Egyptian painting of about 2500 B.C. Major achievements of the Chinese before the Christian era appear in the reclamation of marsh land by polders, the digging of irrigation canals, the cultivation of wet rice, silk spinning and weaving on looms, the casting of bronze, and the making of wheel formed pottery.

The first reference to anything in the nature of a machine, other than the cart, the potter's wheel and the loom, is to a shadoof (Chieh kao) in the writings of Chuang Tzu (about 330 B.C.), who quotes a story of Tzu Kung, one of the disciples of Confucius (about 500 B.C.) in which it figures. About this time (say 300 B.C.), iron began to replace bronze for weapons and to be used for ploughshares in China.

The earliest recorded mechanisms properly so called, other than looms, are the bronze astronomical instruments used in the great calendar reform of 104 B.C. There are no exact descriptions of these, but it seems clear that each consisted of an equatorial or azimuth circle set in a frame with movable sight bars or alidades, i.e., a simple form of transit. The first actual power machine of which we have a record in China is a horizontal waterwheel, with a vertical shaft carrying an upper wheel which was connected by a thong to a bellows pump for blowing a charcoal furnace used in smelting iron. It was improved by Han Chi in

From Paper read at a meeting of the Newcomen Society, held in the rooms of the Royal Asiatic Society, London, on Wednesday, February 11, 1942.

about A.D. 250 by substituting a stiff link-work for the thong, and in this form is illustrated in the technical books of the early Seventeenth Century as a standard appliance. This particular device is of great interest in relation to Bennett and Elton's hypothesis that the horizontal waterwheel was a Greek invention which spread by Gothic routes to Shetland and Ireland. The Chinese example appreciably precedes the known date of the Irish mills. A celestial globe or armillary was made by Chang Heng in the Second Century with a waterwheel drive.

Towards the end of the Second Century, one Pi Feng is said to have devised a chain pump for the Emperor Ling Ti, but the form which is peculiar to China seems rather to have been developed by Ma Chun about A.D. 230. This celebrated mechanician flourished at the court of the Wei dynasty (A.D. 220 to A.D. 264). He is credited with many inventions, mostly of the animated-puppet type. The Chinese chain pump, which is still used very largely for irrigation and for emptying ponds, has often been illustrated. The oldest known Chinese picture of it is in a Thirteenth-Century book of poems on tillage and weaving. It consists of two sprocket spider wheels in a frame, carrying a continuous chain of paddles, linked together. The frame is set on a slope and the chain runs in a box which the paddles fit fairly closely, pushing the water up before them as the chain is driven by the upper sprocket. The latter may be driven by hand cranks, spider-wheel treadles, an undershot waterwheel, or a shaft carrying a small cogged wheel which gears into a large trundler turned by a yoke operated by one or two animals. All the parts are made of wood. The cogs are tapered square pegs set in the felloes of the wheels. It is not certain when a gearing drive was first introduced in China but it may be older than the Third Century. Similar gear was known to Vitruvius in the First Century B.C., and Gunther in his book on astrolabes shows a Greek example of spur gearing. Feldhaus has ascribed a knowledge of the principle of gearing to Aristotle. The Archimedean screw pump does not appear to have been known in China.

The next type of machine, the water pestle, is reported to have been invented by T'u Yü about A.D. 290. Chinese generally eat cereals in the boiled form rather than as baked flour, so that husking is more important to them than grinding. To loosen the husks from millet or rice, heavy hand pestles in mortar pits have long been used. The water pestle consits of a tilt hammer, the head of which acts as the pestle, the tilting is produced by a lug rotating on a horizontal shaft operated by a vertical waterwheel, very much like the mechanism of the Sixteenth-Century Sussex hammer mills. This appears to be the first clear Chinese reference to vertical waterwheels. They seem always to have been undershot.

The following list of items to which the Chinese have a fairly well developed claim for invention is noteworthy:—

Wet rice cultivation.
Silk cultivation and weaving.
The drawloom.
Pulp paper.
Block printing.
Box air pump.
Sedan chair.

Rotary winnowing fan.
Paddlewheel for boats, with treadmill.
Stiffened sails.
Tilt hammer.
Cascade clepsydra.
Deep-well boring.
Magnetic compass for land travel.
Porcelain.
Chain pump.
Balanced wheelbarrow.
Watertight bulkheads.
Reed organ.
Repeating crossbow.
Differential axle.
Lacquer.
Gunpowder for fireworks (not for firearms).

Claims are made to the invention of flying machines, taxicabs, mechanical north-pointing chariots, etc., but some of these are only paper projects and may be only echoes of Heron and other Greek writers. Many of these items are controversial, but some are beyond question. In conclusion, it may be remarked that the Chinese have an old claim to the horizontal waterwheel and the noria; which, at the very least, shows that their adaptability to mechanical invention was by no means behind that of Europe in the years which preceded the exploitation of coal.

—*Engineering.*

Animal Electricity

By Eric Hardy, F.Z.S.

THE lighting of a neon sign by the current produced from an electric eel, which was demonstrated by the New York Aquarium Society, shows the power which can be obtained by animal electricity. In general, the ability to produce powerful charges of electricity as a weapon of defence is confined to four main species. They are the electric ray or torpedo ray, which is an uncommon inhabitant of British waters, the electric eel of the Orinoco River, South America, the thunder fish of African rivers, and the common skate of our own coasts, although in the latter case there is only a small supply of current. In all cases the production of such discharges is exhausting and the fish requires periods for recuperation.

Electric Ray

The electric ray has two kidney-shaped electric organs situated on each side of the head below the eyes, by the gills. They consist of a series of hexagonal prismatic columns side by side, and number 500 to 1,000. Each of these columns in turn consists of 500 superimposed plates or discs separated from one another by an albuminous liquid thus resembling the voltaic pile. They are really modified muscles cells, evolved for defence or predatory reasons. These columns are richly supplied with separate nerves which enter and terminate on the negative sides of the plates. The nerves are derived from four main trunks which come from a special electric lobe of the medulla oblongata at the top of the spinal cord. Nervous stimulation produces an electrical effect in every plate of the column, the total effect producing a powerful charge which can be led through by a conductor. Normally, the current flows through the water and surrounding tissue from the ventral to the dorsal surface of each column, thus completing the circuit. It is strong enough to numb one's hand, but the fish itself is immune from destruction by these electric shocks.

The Eel

The electric eel is not a true eel, although eel-like in shape, and its true name is gymnotus; it is more closely related to the cat fish. It produces a much greater shock than the electric ray. Four very large electric organs run almost the entire length of the body, which in some adult fish reach 6 or 8 ft. long. There is a similar series of super-imposed transverse plates, but the columns are longer, and the plates smaller and more numerous, hence the greater shock, which can kill animals larger than fish. The nerves come from the spinal cord as in the case of the ray. The fish must be remarkably immune from electric currents as each of its own shocks must pass through its own head. The shock may be felt some distance in the water, and it is greatest when the fish is disturbed.

The electric thunder fish, or cat fish, from the Congo, Nile and other African waters has a small body, 6 or 12 in. long. Unlike other electric fish, the organ producing electricity is not in

the muscles but in its skin, which is thickened to form a mantle around its body. There is the same distribution of rows of plates, but there are over four million of them. The enormous nerve supply to work these is derived from two nerve fibres emerging from a single nerve cell in the upper part of the spinal cord, each of these fibres dividing into numerous branches for the two million plates. The shock produced is intense.

Our common British skate has only a feeble electric organ forming a long, tapering body on each side of the tail, and comprising a few columns with a small number of transverse plates. Its electric discharges are too weak to have effect upon other fish.

Animal Luminosity

Animal illuminants are not produced by electricity, it is the result of biological oxidation. In luminous deep sea fish, the fuel is luciferin, a nitrogenous substance similar to proteins, while luciferase acts as a catalyst, essential to the combustion but itself unchanged. The photogenic cell of the "glow-worm" (a beetle) comprises a central mass of large fatty cells where the light originates, and directly behind this is a layer of smaller cells acting as a reflector. Two large trachael-trunks with many branches take air into the cell, and the insect controls this supply of oxygen and thus the intensity of light with the aid of white, thread-like tubes of nerves parallel with these air tubes.—*The Electrical Times.*

Another Form of Bird Trouble

This light training plane managed to land in the position shown in a tree, one wheel lodging in a crotch, but not touching the 8 kv. Hydro rural primary line alongside. The crew climbed out and slid down the tree without difficulty. Fortunately no electric arc occurred to ignite the large quantity of high-test gasoline which was spilled.

The Commission's rural office was notified, and the foreman and a lineman responded. By means of our heavy blocks attached high up in the big tree to the left, these two men, assisted by the Air Force Maintenance crew, lowered the plane without cutting any of the wires and with only a slight interruption to the service.

The Production of High Rotational Speed

Small steel rotors have been suspended by an axial magnetic suspension using inductance control to effect vertical stabilization. They have been spun in vacuum by means of a rotating magnetic field having a frequency of the order of 100 kilocycles per second. Rod rotors tended to precess in the absence of horizontal damping. This was remedied by placing a copper block just above the upper end of the rod. A tapered length of drill rod ⅞ in. long (max. dia. 3/16 in.) reached 36,000 revolutions per second before bending double due to the effect of centrifugal force. Steel balls have the advantage of no precession; however, on starting to spin they soon built up a circular orbital motion of increasing amplitude. A damping needle situated outside the vacuum system and immersed in oil was found to eliminate this motion satisfactorily. A 3/32 dia. ball has been spun to 110,000 revolutions per second.* This corresponds to a centripetal acceleration at the periphery of 58×10^6 gravity. The rate of free deceleration at 106,000 revolutions per second was about 1 per cent per hr. Rotational speed was measured by observing the rotor in stroboscopic light whose frequency could be matched with the speed of the rotor.

—*Science Abstracts.*

*Peripheral speed 1,800 miles per hour.—*Editor*

New C.E.S.A. Standards

The Canadian Engineering Standards Association has recently issued the new standards mentioned below.

A23-1942—CONCRETE AND REINFORCED CONCRETE (SECOND EDITION)

The first edition of this specification was published in 1929, and the second edition which has just been published has been revised extensively to take cognizance of the many developments that have taken place in concrete and

reinforced concrete construction since the first edition was published.

This specification is intended to cover the use of concrete and reinforced concrete in general.

A72T-1942—Alkali Sulphate Resisting Cement

This specification covers alkali sulphate resisting cement which is a modified Portland cement that resists to a considerable degree, the deteriorating action of alkali sulphates on concrete.

C.E.S.A. ELECTRICAL STANDARDS

The following two revised standards are Approvals Specifications under Part II of the Canadian Electrical Code, the requirements of which must be met in order to obtain C.E.S.A. approval of the electrical devices concerned.

C22.2 No. 14-1942—Industrial Control Equipment for Use in Ordinary (Non-hazardous) Locations—(Second Edition)

This specification applies to control and protective devices for electric motors and for industrial-heating apparatus, for potentials up to and including 2,500 volts between conductors on ungrounded systems and 4,500 volts between conductors on grounded-neutral systems, and intended to be employed in accordance with the Rules of Part I of the Canadian Electrical Code.

It should be noted that electrical instruments, such as meters, which may be mounted along with control apparatus as part of control equipment, are not covered by this specification.

C22.2 No. 42-1942 — Receptacles, Plugs and Similar Wiring Devices (Second Edition)

This specification is intended to apply to:

(a) Attachment-plugs (caps and adapters), cord connectors, motor attachment-plugs and current taps, rated at 20 amperes and less, at 250 volts and less, designed to be employed in accordance with the Rules of Part I of the Canadian Electrical Code.

(b) Receptacles and plugs rated at 200 amperes and less at 750 volts and less designed to be employed in accordance with the Rules of Part I of the Canadian Electrical Code.

It should be noted that lampholders, and pull-off plugs for electrothermal appliances, are not included in this specification.

The Characteristics and Manufacture of Fibred Glass

DISCOVERY of a process by which refined molten glass could be drawn into fibres 15 times finer than a human hair, with all the pliability of silk, and with infinitely greater resilience and tensile strength, presented the insulation engineer with something that had long been regarded as an impossible figment of the scientific imagination. What was formerly a rigid, cranky and perishable material had suddenly become a docile, adaptable, and enormously efficient agency of insulation.

Here, in short, was a material as workable as cotton or asbestos, without the bulk of either, and without the liability to deterioration under high temperatures or in certain atmospheric conditions. Its application to electrical insulation problems has been rapid and extensive, paralleling a similar application to the problems of thermal insulation.

The apparently simple process of drawing the molten glass into gossamer filaments begins with the formation of highly refined glass into marbles about ¾ in. in diameter. This is to facilitate inspection for flaws. Having been found individually flawless, the marbles are run into an electric furnace developing 2,700 deg. Fahr., which converts them into liquid glass. Through 204 tiny openings in precious metal bushings the molten glass emerges as filaments so fine as to be almost invisible. As they emerge from the furnace, these gossamer strands are gathered together and conducted through an opening in the floor onto a winder below, which draws the combined filament out into a continuous fibre as much as 5,000 miles in length. A single glass marble will produce a filament 97 miles long. In the process of drawing and winding, the filaments travel at the rate of a mile a minute.

This gives some idea of the tensile strength of these "ropes of sand." To be exact, it is about 500,000 lb. per sq. in. whereas the finest hard-drawn steel piano wire has a tensile strength of only 330,000 lb. per sq. in.

Yet this combined strand of 204 filaments is still too fine for textile processing; at least two of them must be twisted together to form the finest workable yarn or thread. This is done on a standard textile machine, which twists the strands together to form any desired thickness. The interesting thing is that although from the time the 204 filaments are twisted into a single strand all heat has departed from the glass, there is practically no breaking or splintering. An intractable and brittle solid has become as pliable and workable as silk or cotton.

Weaving of this "glass yarn" is done on ordinary looms, such as are found in all textile mills. Not only can it be woven into tapes, braids and cords, but into fabrics of full-loom width, and of marvellous sheen and beauty. All of these fabrics are non-inflammable, mildew-proof, rot-proof and washable.

—*Modern Power and Engineering.*

Unused and Surplus Stock

Municipal Hydro Systems may file a copy of the report they have already made to the Metals Controller showing surplus and unused stock, with the Priorities Officer of The Hydro-Electric Power Commission of Ontario.

In this way, surplus stocks held by the Municipal Systems may be recorded and redistribution arranged and mutually agreed upon by the Municipalities. The purchase of new equipment avoided will thereby materially aid Canada's War Effort.

Many Municipalities have already co-operated by filing their reports. Address your lists and requests for information to:

Priorities Officer,

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

620 University Ave.

Toronto

Municipal Loads, March, 1942

NIAGARA SYSTEM

25 and 66-2/3 Cycle

	H.P.	Population
Hamilton	156,163	163,768
St. Catharines	27,338	30,406
Trafalgar Twp.	447	V.A.

66-2/3 Cycle

	H.P.	Population
Bronte	121	P.V.
Oakville	1,028	3,869

GEORGIAN BAY SYSTEM

60-Cycle

	H.P.	Population
Alliston	323	1,700
Arthur	129	1,089
Barrie	3,621	9,521
Beaverton	203	941
Beeton	96	617
Bradford	242	1,041
Brechin	39	P.V.
Cannington	155	761
Chatsworth	60	333
Chesley	464	1,812
Coldwater	105	545
Collingwood	2,279	5,636
Cookstown	71	P.V.
Creemore	112	661
Dundalk	196	686
Durham	322	1,874
Elmvale	128	P.V.
Elmwood	51	P.V.
Flesherton	55	452
Grand Valley	105	645
Gravenhurst	1,048	2,261
Hanover	1,298	3,190
Holstein	13	P.V.
Huntsville	1,153	2,943
Kincardine	683	2,483
Kirkfield	26	P.V.
Lucknow	306	1,977
Markdale	164	776
Meaford	671	2,759
Midland	3,725	6,627
Mildmay	115	764
Mount Forest	403	1,936
Neustadt	47	431
Orangeville	683	2,558
Owen Sound	4,849	13,599
Paisley	119	730
Penetanguishene	953	4,177
Port Elgin	372	1,415
Port McNicoll	78	950
Port Perry	224	1,175
Priceville	10	P.V.
Ripley	86	420
Rosseau	29	305
Shelburne	237	1,053
Southampton	462	1,467
Stayner	236	1,106
Sunderland	74	P.V.
Tara	85	510
Teeswater	113	873
Thornton	28	P.V.
Tottenham	75	532
Uxbridge	263	1,480
Victoria Harbour	70	979
Walkerton	873	2,534
Waubaushene	62	P.V.
Wiarton	277	1,750
Windermere	12	117
Wingham	635	2,149
Woodville	54	439

EASTERN ONTARIO SYSTEM

60-Cycle

	H.P.	Population
Alexandria	195	1,976
Apple Hill	36	P.V.
Arnprior	1,075	4,019
Athens	94	626
Bath	28	325
Belleville	6,783	14,876
Bloomfield	82	636
Bowmanville	2,787	3,850
Brighton	310	1,462
Brockville	4,417	10,463
Cardinal	240	1,602
Carleton Place	1,561	4,143
Chesterville	243	1,094
Cobden	82	643
Cobourg	2,143	5,062
Colborne	183	960
Deseronto	167	1,002
Finch	82	396
Hastings	94	823
Havelock	129	1,103
Iroquois	196	1,123
Kemptville	350	1,230
Kingston	12,267	26,741
Lakefield	290	1,301
Lanark	82	686
Lancaster	43	570
Lindsay	3,632	7,241
Madoc	193	1,130
Marmora	122	1,004
Martintown	32	P.V.
Maxville	100	811
Millbrook	79	749
Morrisburg	201	1,484
Napanee	1,197	3,241
Newcastle	191	701
Norwood	124	710
Omemee	199	630
Orono	81	P.V.
Oshawa	16,985	25,035
Ottawa	33,802	150,277
Perth	1,617	4,197
Peterborough	12,111	24,400
Picton	1,024	3,400
Port Hope	2,294	4,997
Prescott	1,220	3,120
Richmond	55	428
Russell	58	P.V.
Smiths Falls	2,560	7,741
Stirling	233	947
Trenton	4,575	7,636
Tweed	199	1,181
Warkworth	74	P.V.
Wellington	142	948
Westport	89	725
Whitby	1,261	4,236
Williamsburg	88	P.V.
Winchester	281	1,017

THUNDER BAY SYSTEM

60-Cycle

	H.P.	Population
Fort William	14,879	30,317
Nipigon Twp.	170	V.A.
Port Arthur	38,601	23,790

NORTHERN ONTARIO PROPERTIES

Nipissing District

60-Cycle

	H.P.	Population
North Bay	4,221	16,013

Patricia District

60-Cycle

	H.P.	Population
Sioux Lookout	300	1,967

Sudbury District

60-Cycle

	H.P.	Population
Capreol	215	1,660
Sudbury	8,150	32,731

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Ontario Hydro-Electric Power Commission

The BULLETIN

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The Hydro-Electric Power Commission of Ontario

Volume XXIX MAY, 1942 Number 5

One hundred and ten kv, double circuit tower line in Don Valley.

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THE
BULLETIN

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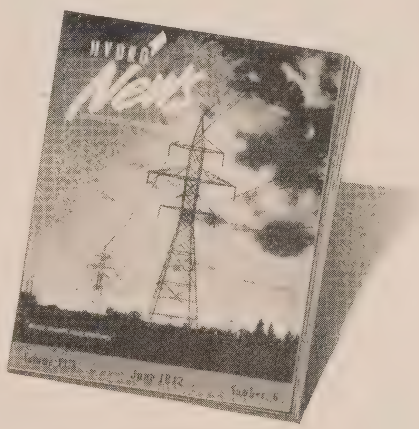
Marking a Milestone

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

NEXT month an important milestone will be attained in the history of *The Bulletin* when its name will be changed to *Hydro News,* inaugurating a new policy designed to increase its usefulness.

During 28 years of continuous publication, *The Bulletin* has maintained a consistently high standard of accuracy and usefulness in the presentation of material bearing on the activities of The Hydro-Electric Power Commission of Ontario. At the same time, it has established a reputation as a technical journal through the publication of informative articles prepared by engineers and officials of the Commission and the associated municipal utilities.

In acquainting municipal commissions and councils with the activities of the Commission, and by serving as a medium for the dissemination of a more general knowledge of electrical matters, it has held steadfastly to policies which were laid down when the first issue came off the press in April, 1914.



Cover design of the first issue of the Hydro News which will be published in June.

During the intervening years, the development of practically all phases of industrial, commercial and domestic life in Ontario has been synonymous with the growth of Hydro, while the past two and a half years of war have brought about a dramatic transition in the scope and tempo of industrial production. These facts,

combined with the ever-changing panorama of world events have opened up new and broader vistas of interest in which the functions of Hydro assume still greater significance.

To meet these changing conditions, which demand a new and more virile form of editorial interpretation, *The Bulletin* will modify its role as a technical publication and accentuate its mission as a Hydro family house organ.

As *Hydro News,* it will seek to portray all phases of Hydro activities in a well-illustrated magazine style.

Just as *The Bulletin* in the past sought to create a close liaison between the Commission and the associated municipal utilities, *Hydro News* will seek to engender a closer co-operative spirit among municipalities and between the municipalities and the Commission.

The background and experience of the men who will serve on the advisory editorial board promise a continuity of outstanding service to a still wider circle of readers.

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Vol. XXIX **No. 5**

May, 1942

The purpose of the Bulletin is to furnish information regarding the Hydro Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Accident Prevention Methods and Results

By Wills Maclachlan

WITH the country at war it is of importance that men and material shall not be wasted but shall be used in the most effective manner. The wastage from accidents in industry and in war industry has disproportionately increased since the speed-up began.

The industries in Schedule 1 of the Ontario Compensation Act do not include the railways, the Bell Telephone Company, The Hydro-Electric Power Commission, many municipal and all governmental defence operations. Excluding these, the compensation cost of accidents in 1940 was $8,370,000, a dead loss from our badly needed resources. This sum would have bought 14 corvettes but it represents only one-fifth of the loss because it has been proved repeatedly that "compensation payments constitute only one-fifth of the total employer accident cost." Where can effective ideas, methods and means be found to stop or reduce this loss?

The electrical public utilities of Ontario have been carrying out organized accident prevention work since 1915. Certain methods have been developed; certain objects have been achieved; a review of these may assist in solving the general problem.

The following notes refer chiefly to a group of public utilities in the province of Ontario. A large amount of accident prevention work has been done in other provinces and in industries other than the electrical public utilities, but this paper is based on facts and methods that have come under the author's personal observation.

In 1914 the Legislature of the Province of Ontario passed a Workmen's Compensation Act; this being the result of study by a Royal Commission headed by Sir William Meredith. The fundamental basis of most Workmen's Compensation Acts is the same, and, quoting from the Ontario Act, may be stated as follows:—

> "Where in any employment . . . personal injury by accident arising out of and in the course of employment is caused to a workman, his employer shall be liable to provide or to pay compensation in the manner and to the extent hereinafter mentioned." . . .

There are various methods by which the employer can provide this compensation. In Ontario there are two: First, under Schedule 1 of the Act, by paying an assessment on payroll to the Compensation Board, the Board assuming the responsibility for the payment of all costs under the Act. Second, under Schedule 2, by the employers being individually liable for the payment of the said costs on direction of the Board. By far the greater part of employment is placed in Schedule 1. In certain other acts of this character provision is made for injured workmen's compensation by the employer

Paper presented before the General Professional Meeting of the Engineering Institute of Canada, at Montreal, Que., on February 6th, 1942.

taking out insurance with a regular insurance company; this is a more expensive method than that in effect in Ontario and Quebec.

The Ontario Act provides for the formation of associations of employers for the prevention of accidents, it being better to prevent an accident than to pay compensation. Classes and groups of employers are recognized, and these associations, usually embracing industries of a like character, are managed by committees of employers in the respective classes. The Workmen's Compensation Board has authority to approve such an association if it believes that it sufficiently represents a class and in its assessment of the class obtains sufficient money so that it can make a grant to the association to carry out its work. Such a one is the Electrical Employers' Association of Ontario. It was brought into being in December, 1914; was approved by the Board and has been carrying out its functions since January 1st, 1915. It deals primarily with accident prevention among employees of the electrical public utilities and telephone systems, placed by the Workmen's Compensation Board under Schedule 1 of the Act, and now for the most part contained in groups 220 and 221. This Association is governed by a Managing Committee. Serving as presidents at different times have been some prominent members of the Engineering Institute of Canada, to mention but four: the late A. A. Dion, R. L. Dobbin, W. H. Munro and the present president, R. Harrison.

The Problems

What are the conditions in the electric public utility industry that increase liability to accidents? The first is scattered employment. In any public utility, the employees are dispersed over a city, town or a large part of the countryside, working for the most part in small groups, often without close supervision. The next condition is the constant hazard, particularly in the electric power industry, of electrical shock or electrical burns. There are many peculiar hazards that develop in the operation and maintenance of power houses and substations, due to the necessity of installing machinery in a confined space and also due to the fact that much of this equipment is energized. The overhead system of a public utility develops another type of hazard. Such a system has to be maintained in all weathers, the butts of poles being subject to rot and in cities the pole tops often being encumbered with cross arms and equipment. Adding to the hazard is the fact that it is important to maintain, as far as possible, continuity of service and hence the necessity at times of working close to or on either moving machinery or energized apparatus or lines. Analogous to this last mentioned hazard is the difficulty of removing apparatus or lines from service and returning them to service. To enlarge slightly on this: a transmission line operating at 44,000 volts needs some insulators removed because of broken petticoats; arrangements have been made to make the line dead so that the men can work on it. The risk is ever present that the line may inadvertently be put back into service prematurely.

Men are supervising, managing and operating public utilities; many machines are involved, but in addition the frailties of human nature are always present.

How Have Some of These Problems Been Met?

1. Engineering Revision and Design

Consider an example. In 1915 and for

some years after, it was common practice to install a number of disconnecting switches side by side on a switchboard or structure in a power house or substation. After the load was taken off a circuit by the oil switch being opened, the operator's problem was to open the disconnecting swiches on each side of the oil switch or piece of apparatus. With a number of disconnecting switches on the switchboard or structure, there were times when he would open two blades of the circuit that was de-energized and then by mistake a blade in an adjacent live circuit, drawing an arc which at times enveloped the operator, resulting in severe burns or death. This problem was met first, by putting insulated baffle boards between the individual blades of the disconnecting switches of each circuit and, secondly, by clearly naming all disconnecting blades that constituted the disconnecting switch of the circuit. By this means even if the wrong blade was opened, the baffle board often prevented a short circuit arc from developing and the clear naming and designating of the switch was a constant indication to the operator of the blades constituting the circuit. This system of segregation, spacing and marking switches and apparatus and thus clearly designating them, was rapidly extended to the whole of the power house or substation equipment, including power transformers and other major equipment, and materially reduced accidents caused by employees straying into live apparatus.

Still another example of engineering revision: In earlier designs the fly-balls of a governor rotated in the air. Some of these fly-balls were at elbow height and operators' elbows have been fractured by being hit by the fly-balls, so that guards were installed. Later, more effective design was developed by enclosing the fly-balls, making for constant windage, better lubrication and a safe design.

Again, in the development of pole type transformer installations, a very considerable improvement has been made, not only in the service to the consumer but also in safety for the lineman, by creating more elbow room for the workman, perfecting the type of cut-out, re-arranging and improving the whole grounding system, particularly making provision for grounding of transformer cases, and in some later designs making it possible to entirely kill all wires and circuits below the line arm.

In all utility property, the exposed non-current carrying metal parts, such as frames of motors, are effectively grounded. This is to prevent the employee who places his hand on the motor frame from receiving a severe shock if the motor has broken down between coil and frame. This same hazard exists in motors in the manufacturing and other industries but many do not seem to realize the importance of grounding these frames.

2. Tools and Equipment

Tools and equipment enter into many accidents in electric public utilities. One piece of equipment may be mentioned. Formerly there were many cases in which a lineman's belt broke, dropping the lineman, often resulting in serious injury and sometimes in fatal results. A study was carried out in connection with linemen's belts. The hardware had been adapted from horse harness hardware, but the snaps were malleable and at times had blow holes and broke. Drop-forged steel snaps were developed. The D rings in the earlier belt were sewed on the outside of the main body belt; if the stitching or rivets gave way, the man would fall. On

redesigning, the body belt was placed through the D ring and the D rings made of drop-forged steel. Advice from leather manufacturers was obtained, a better grade of leather was developed and advice given to linemen for the maintenance of the belts. These details were worked out and the matter placed before a Canadian manufacturer who produced a very satisfactory belt.

In the early days the lineman supplied his own belt, but since, if the belt failed, the employer paid the cost of the accident, the practice developed of the employer providing the belt. This has resulted in a better belt more adequately maintained.

Since the perfected belt went into service some years ago, not one accident has occurred in Ontario to a lineman through failure of this belt. The same method of careful analysis of tools and equipment has been applied to rubber gloves, ladders, line hose, insulator caps, rubber blankets, and other items of equipment.

3. Methods of Work

Various methods of doing work were investigated. As was pointed out earlier, one of the distinct hazards in electric public utility work arises in taking a piece of apparatus out of service for work and replacing it in service. This in the old days was guarded against by a clearance rule which with the more complicated systems, has developed into regulations filling many pages of the rule book. The essential features are:

That the foreman shall obtain permission to take the piece of apparatus out of service. This frequently necessitates the approval of a senior official. At the time that the work is to be done, the holder of this permit, usually the foreman, and the operator who receives the permit, see to it that the necessary switches or valves are put in such a position that the piece of apparatus is taken out of service and de-energized. If it is electrical apparatus it is thoroughly grounded and not until that time is it considered dead. Tags giving the name of the man holding the permit are placed on the valves or switches stating that the apparatus is out of service. These tags cannot be removed nor can the apparatus be put back into service without the holders' permission. In transmission line work, it is also necessary to place grounds on each side of the working space. Not until the foregoing is completed is work allowed to commence.

After the work is completed, the foreman makes sure that all working grounds are removed, every man under his supervision is clear and all possibility of contact with the apparatus or line is prevented. Not until this is done does he return his permit and turn it over to the operator.

Although this rule is enforced by all public utilities and is applicable to industry, in ammonia tanks, cranes, industrial substations, air lines, etc., it has not yet received the consideration that it should from those in charge of some manufacturing concerns.

Another simple but very important rule is that some one person should be in definite charge of a power house or substation or control desk at any instant. There should be no divided responsibility. For example at the time of a change of shift, there is danger of the operator and his relief being uncertain as to who is in charge of the power house. This point has been most clearly defined in rules. In one utility the relief does not take

over until he has read and signed the log. Every utility man with long experience can remember cases where the lack of such a rule resulted in a near accident or a fatal accident.

4. Human Factor

Up to the present we have been dealing with the correction of machines and methods of working. Men, however, are doing the operation and maintenance, and the psychological factor must not be overlooked. In certain kinds of work, habit training is of great value and is definitely indicated. This is important in connection with artificial respiration but it is equally applicable in many other phases of the work. For those who have investigated many accidents, the possibility that an experienced man may do something that one would never expect him to do under normal circumstances, is a very considerable worry. One example of this is that of an experienced employee, who while thinking of something entirely foreign to his work, goes in on clearly marked and designated live apparatus, instead of dead apparatus. Methods have to be developed to assist the man in keeping his mind on the job at critical moments and in hazardous conditions. One simple method has been the instruction to a lineman in climbing a pole to stop 4-ft. below the lowest cross-arm or attachment, put his belt around the pole, have a good look at the pole top, figure out exactly what he is going to do and then go ahead and do his job.

The choice of the suitable man for each type of employment must not be overlooked. A man might be ideal in the operation of a substation but unfitted for the operation of a power plant. A man who would make a splendid lineman might be out of place on a patrol beat. It is not only the physical make-up of the man that is to be taken into consideration, but also his whole personality. If this is important in connection with the rank and file of employees, what of management? Employees must be impressed with the sincerity of management in its endeavour to prevent accidents. It is quite possible to get quick results for a very short period of time by publicity methods, but nothing will replace the mutual confidence between management and employee for the long pull in accident prevention work or for that matter in any phase of employment.

5. Methods of Correction After the Accident

Given that an accident has happened, the immediate effort becomes one to mitigate or reduce serious consequences, and secondly, an effort to prevent repetition.

Speaking first of mitigation, detailed first aid kits in line with the requirements of the Workmen's Compensation Board adapted for the use of public utilities have been recommended and training in the use of the kits and in simple first aid put forward. Extensive training in first aid has not been recommended, but that pertaining to the public utility field has been specified.

Because of the fact that electrical shock is such a major hazard in the electrical public utility field, a very large amount of time and effort has been expended on this factor. In the early days, methods were crude, so with the co-operation of medical associations and the universities, research into the effect of the passage of electrical current through the body was instituted. While this laboratory research was being done and detailed information of actual cases collected from the field, a careful study was made of all the engi-

neering and medical literature available on this subject. As a result of this work, much information was gained and a practical system of remedial measures after electrical shock was developed.

As it was clear from the studies that these measures must be put into effect without delay after electrical shock, training of all employees in artificial respiration was taught, so that the man closest to the injured would know what to do. In view of the fact that after an accident there is a great tendency for people to lose their heads, constant practice in artificial respiration was required among employees, so that by habit training, these men would be prepared to carry on artificial respiration even though very much excited. Rescue methods were also taught. Co-operation of doctors and nurses was obtained by giving talks and demonstrations in universities and hospitals and before various medical bodies and preparing papers for the medical technical press. As a result of this, many lives have been saved. One case of outstanding character may be cited.

In 1927, about two o'clock one afternoon, a young lineman brought his head into contact with a high tension overhead wire. His feet and hands were in contact with conductors which were grounded. He received a very severe shock and was apparently lifeless, hanging back in his belt. He was removed from the pole, artificial respiration was started at the foot of the pole, medical assistance called, and telephone communication established with headquarters. About 1½ hours later he was removed to hospital; artificial respiration was continued during transportation and was continuously applied in the hospital. All this was done by public utility men. About ten o'clock that night, they had the man breathing without assistance. This had required eight hours of continuous artificial respiration after electrical shock—the longest case on record.

After an accident, particularly of a serious character, an investigation is usually carried out, but much of the value of these investigations has been lost. If those holding an investigation would not only ascertain the facts but would learn what should be done to prevent repetition and see that such measures are put into effect, much of value would be obtained. Investigations merely to fix the blame are largely a waste of time as it will be found that what one is really discovering is an alibi. Real information has been driven under cover. If, however, the blame is fixed the next step usually is discipline. This develops fear and frequently results in more accidents. Nothing is gained. Time is wasted and valuable information that would have helped to prevent a recurrence is lost.

One phase of mitigation that should be touched upon is that of rehabilitation. At times a lineman is injured in such a way that he cannot continue to be a lineman. How can he be rehabilitated to become a useful citizen? Two approaches are at present in use: first by physio-electro and occupational therapy the man is assisted in overcoming the results of the accident; the injured muscles and nerves are made well and the mental outlook improved. A splendid curative clinic working to this end is maintained by the Workmen's Compensation Board of Ontario. Secondly, by re-education and retraining in schools and industry, the man is prepared to take a new job suitable to his condition. Such rehabilitation is not easy to carry out but anyone assisting to forward the work,

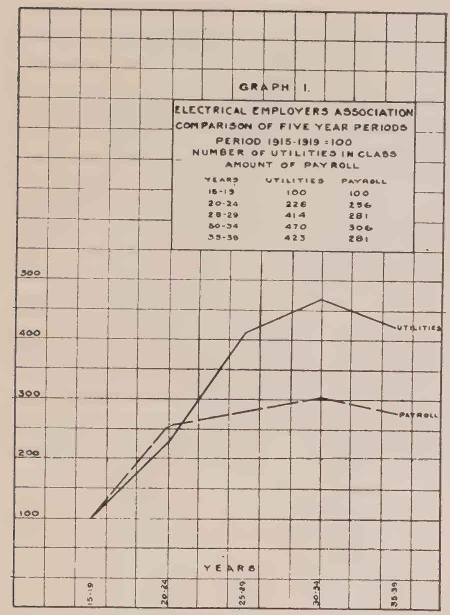

Fig. 1—Number of utilities and amount of payrolls.

will be thoroughly recompensed in seeing some cases carried through to success.

It must not be assumed that this account covers all the various applications employed. Engineering revision and all of the other methods are used in many other ways but these are examples. In addition to this, talks with employees and management, letters and bulletins and the usual forms of approach have been tried, and where successful, proceeded with.

Results

What have been the results of accident prevention in the Electrical Employers' Association during the twenty-five years 1915 to 1939?

Records have been kept over this period. They have been checked by the statistical department of the Workmen's Compensation Board of Ontario and are in agreement with their records,

As the experience varies from year to year, it has been thought wise to take five-year periods and group the accidents, costs of accidents, and other information within these periods. As a means of comparison, the experience for the years 1915-1919 has been taken as a control and assumed to be 100.

Number of Utilities and Amount of Payroll

Figure 1 is a graph showing the increase in the number of utilities in the class and the payrolls for each five-year period taken as a percentage of the five-year period 1915-1919. It will be seen that there was a substantial increase in the number of utilities in the class up to the five-year period 1925-1929; it then shaded off and for the last five-year period there is reduction from the peak. This has been due to a number of different causes: the amalgamation of different utilities into one; some utilities being removed entirely from the utility field and other employers placed in the class for a few years, for example, construction industries were removed from the class, as their work is foreign to that normally done by public utilities. The payroll showed a sharp increase until the period 1920-1924, then a slight increase since that time. This is due to the fact that some of the larger utilities were bought out by those not in the class and to a very great extent in the latter years the utilities entering the class have been of a smaller character.

Frequency of Accidents

In Fig. 2, is shown the frequency for,—

Total lost time accidents
Temporary disability accidents
Permanent partial disability accidents
and
Fatal accidents

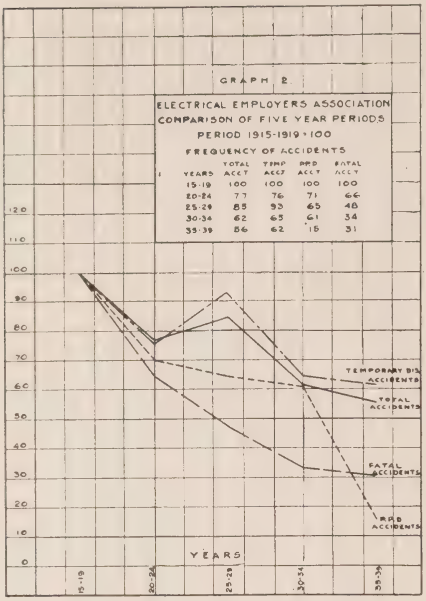

Fig. 2—Frequency of accidents per one million dollars payroll.

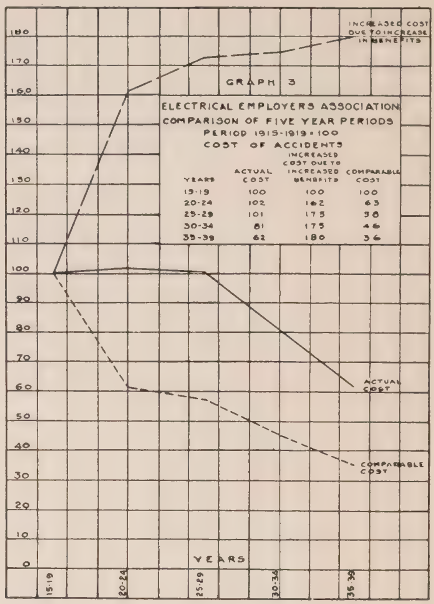

Fig. 3—Cost of accidents per one hundred dollars payroll.

The frequency for this graph has been taken as so many accidents per million dollars payroll. It has not been possible to use the more usual comparison of accidents per so many man-hours. This again is for each five-year period, compared with the 1915-1919 period as 100. The sharp increase for the period 1925-1929 in the number of temporary disability accidents is due to the fact that during this period the construction companies were in the class and have since been removed. It will be noted that for the last five-year period under consideration, the fatal accidents per million dollars payroll were less than one third of what they were in the period 1915-1919 and the permanent partial disability accidents were but 15 per cent of what they were in the earlier period.

Cost of Accidents

In Fig. 3, the cost of accidents has been compared on the basis of cost per $100.00 payroll; the solid line shows the actual expenditure by the Board. It will be seen that this actual expenditure for accidents for the period 1920-1924 was slightly over that of 1915-1919 and in 1925-1929 there still was a slight increase; all this seems contrary to what could be inferred from Fig. 2. The last two five-year periods show a sharp reduction. However, when one remembers that amendments to the Act brought in from time to time made the benefits to the injured employee (and hence costs) greater than for the earlier years of the Act, the trend of this actual cost line is explained. With the co-operation of the statistician of the Workmen's Compensation Board of Ontario, a curve of the increased cost of comparable accidents due to increased cost in benefits was worked out and this is shown in the graph. By applying this curve of increased

cost due to increased benefits to the actual cost of accidents, a curve is obtained showing what the costs would have been had there been no increase in benefits. This latter curve is a true comparison of the five-year periods with one another and shows a very marked reduction in cost over each of the five-year periods. This reduction in cost, in part at least, can be attributed to accident prevention efforts.

CONCLUSION

In carrying out any accident prevention work, it is most important that a realistic approach be maintained. The prime object before anyone should be to get facts. If this is kept in mind, then naturally the object of any investigation of an accident is to learn the cause and provide measures to prevent a recurrence and not to find out who is to blame. Arising out of this, design of plant or equipment to be efficient must be such that it is safe to install, manufacture, operate and maintain. Rules and instructions should be simple, practical. They should be enforced or else removed. Even with these essentials the sincere leadership of management is vital to the whole matter. Canada needs every man on the job and not in a hospital bed.

Form Factor

By F. K. Dalton, Testing Engineer, H.E.P.C. of Ontario

AT the present time, the use of the Average Voltage Voltmeter is being advocated more than formerly for correction of errors or inaccuracies in the measurement of transformer core loss and exciting current where the wave form of the supply voltage differs from the pure sine wave. In this connection reference frequently is made to the Form Factor of the voltage as an expression for the shape or form of the alternating wave.

The American Standards Association, in its recommended "Test Code for Transformers", suggests the Average Voltage Voltmeter as a means of improving the accuracy of core loss measurements and calls for a set of readings at different form factors to determine the true value of the exciting current.

The interpretation of Form Factor, however, is not very well understood generally and its limitations not fully recognized. It is often considered a more definite factor than it actually is. This discussion and the illustrations, therefore, have been prepared to show the application of form factor to some different forms of waves, its interpretation in certain instances and its unreliability in other cases. The information will serve as a guide in the proper use of the term.

The Form Factor of an alternating voltage or current wave has been defined as the ratio of the root-mean-square value of the wave to its arithmetical average value. This factor, within certain limits, gives useful information regarding the shape of the wave, indicating whether it is peaked or flat-topped, and to what extent.

Instruments indicating arithmetical

average values are used in conjunction with ordinary alternating current voltmeters and ammeters in determining the form factor of a wave, or it may be found from an oscillograph record by the usual graphical methods.

RMS Values

Alternating current voltmeters and ammeters indicate root-mean-square values. These instruments depend upon the current passing through a coil to establish the field in which the moving coil or armature is placed, and the instantaneous value of torque then is proportional to the square of the instantaneous value of the voltage or current. With any of these arrangements, both the positive and negative half cycles give positive torque. Due to the inertia and damping of the moving parts, the pointer stands in the position of mean torque, which is the mean of the squared values of the current through the instrument,—i.e. the mean-square value. By calibration of the scale alone, the pointer indicates the square root of this mean square value, usually referred to as the rms value.

Arithmetical Average Values

The arithmetical average value of a wave is the average of the instantaneous values through a half cycle, or through one or more complete cycles but with the negative half cycles erected by means of a rectifier so that the negative values do not neutralize the positive values. Without rectification, the average value of any balanced alternating wave would be zero, and, consequently, the reading would be useless.

The permanent magnet type of direct current instrument, having a fixed field strength, will read linear average values. When supplied through a full-wave rectifier, it will read the arithmetical average value of an alternating wave. If the wave crosses the zero line more than twice per cycle, negative loops are formed but these will be erected and included as positive values.

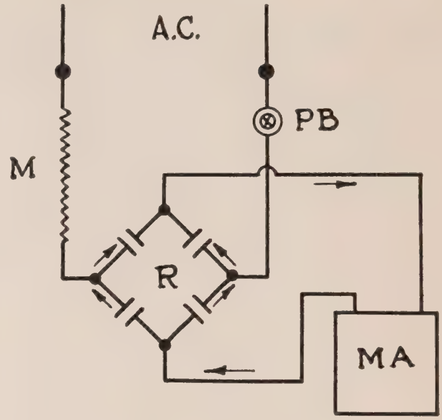

Fig. 1—The Average Voltage Voltmeter, consists of a fixed resistance or multiplier, M, a full wave rectifier, R, and a standard milliammeter, or voltmeter element. The push button, PB, is added to keep the circuit open for protection of the rectifier when the milliammeter is not connected.

Such a rectifier type of instrument, in the form of a voltmeter, is now in use by some laboratories and manufacturers and is known as an "Average Voltage Voltmeter", a circuit for which is shown in Fig. 1. The copper oxide rectifier has been found very satisfactory for this purpose.

Pure and Distorted Waves

For the pure sine wave of either voltage or current,

RMS Value $= 0.707 \times$ crest value
Arithmetical Average $= 0.637 \times$ crest value
Then, Form Factor $= 0.707/0.637 = 1.11$ for the true sine wave.

The alternating wave may be distorted by superimposition upon it of harmonics, i.e. sine waves of higher frequencies that are mutiples of the fundamental frequency. These harmonics may affect the rms and arithmetical average values in different proportions, thus changing the form factor, and even may reduce the average value while increasing the rms value. The harmonics are known, according to their frequencies, as the second, or double harmonic, the third, or triple harmonic, the fourth, or quadruple harmonic, etc. In alternating current engineering, however, the waves usually are balanced, the negative half cycles being the same size and shape as the positive half cycles, which condition excludes the "even" harmonics,—the second, fourth, sixth, etc. Where iron is being magnetized, the third harmonic may be prominent, and higher "odd" harmonics,—the fifth, seventh, ninth, etc.—also be present but to a lesser degree.

The Effects of Harmonics

The root-mean-square value of a wave which contains only odd harmonics may be calculated by the following formula,—

$$\text{rms value} = 0.707\sqrt{E_1^2 + E_3^2 + E_5^2 + E_7^2 + \text{-------}}$$

where E_1, E_3, E_5, E_7 ----- are the crest values of the fundamental, third, fifth, seventh etc., harmonics, respectively.

It will be seen from this formula that the phase positions of the harmonics on the fundamental wave do not affect the rms value. This value depends only upon their amplitudes. The addition of any harmonic increases the rms value of that wave.

On the other hand, the arithmetical average value is seriously affected by the phase positions as well as the amplitudes of all harmonics present. In addition, resultant negative areas are erected and included as positive areas. A formula for the arithmetical average value, therefore, would be extremely complicated except for the special conditions where the harmonics are so placed that they all pass through the zero value at the same instants that the fundamental wave crosses the zero line. It does not appear feasible then to express a general formula for the arithmetical average value of an alternating wave. With the exception of the special cases mentioned, and even beyond certain limits in these cases, it is necessary to obtain the average value by graphical methods or by means of suitable indicating instruments.

The addition of any "odd" harmonic to the fundamental sine wave may either increase or decrease the arithmetical average value of the wave, according to the position of that harmonic. In some special positions it would not change the value. However, when the harmonics are of sufficient magnitude and so placed that their combined wave has a steeper front than the fundamental wave, and has the opposite polarity at the start, the resultant wave will pass through zero more than twice per cycle. There would then be small negative loops which, as previously mentioned, the average voltage voltmeter due to its rectifier, would include as additional positive areas. Such conditions cause some of the complications when attempting to establish a formula for calculating arithmetical average values of alternating waves. All additions to the average values tend to reduce the form factor, and vice versa.

Wave Forms and Form Factor

The rms voltmeter and the average voltage voltmeter are both calibrated to read the same values on direct current. It

SQUARE TOP WAVE

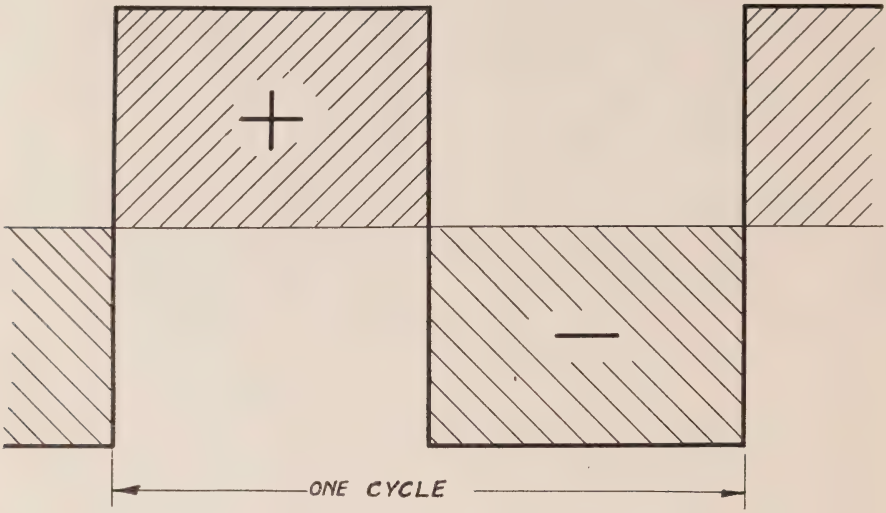

Fig. 2—The Square Top Wave, composed of a fundamental wave and a long series of harmonics. Form Factor, 1.00.

follows then that their indications would be equal when a square top voltage wave of the form shown in Fig. 2, is applied to their terminals. The form factor of this wave therefore is 1.0.

On a pure sine wave, the rms voltmeter gives an indication 11 per cent higher than that of the average voltage voltmeter, the form factor being 1.11, as already explained.

Effects of Third Harmonics

In circuits where iron is being magnetized alternately, in one direction and then in the other, the exciting currents and also the voltages may have prominent third harmonic components. Higher harmonics are usually of lower amplitude and less important in their effect on the form factor of the wave.

A number of waves have been plotted to show the effects upon wave form of third harmonics of various amplitudes, and in certain chosen positions. The resulting form factors also are given.

The waves in Fig. 3 contain the fundamental wave and a third harmonic, the harmonic having an amplitude equal to 20 per cent of that of the fundamental. In wave A, the harmonic is placed so that its positive crest occurs at the same instant as the positive crest of the fundamental. This gives a peaked wave, with form factor of 1.212. In wave B, the harmonic is reversed, i.e. the negative crest of the harmonic occurs with the positive crest of the fundamental. The result in this case is a flat-topped wave, with form factor of 1.06. Now, if this harmonic be so placed that it passes through zero, going either up or down, on the instant that the fundamental reaches its crest value, either positive or negative, as shown by wave C, the form

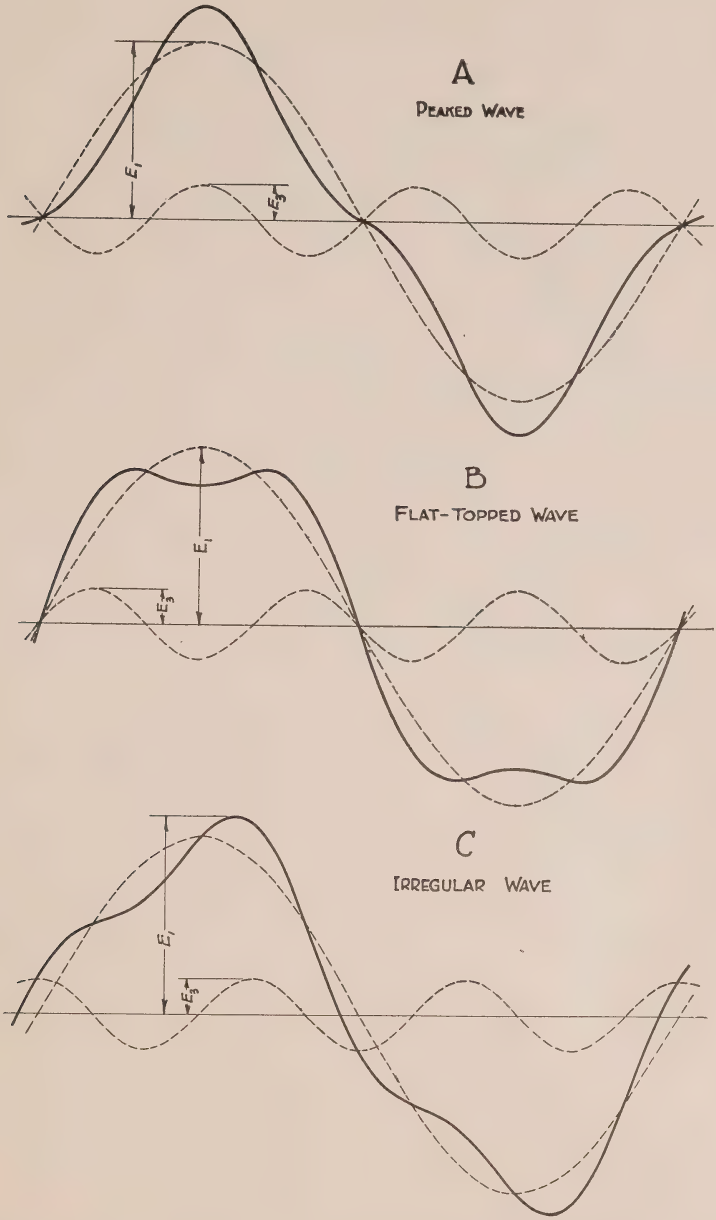

Fig. 3—Wave Forms, composed of a fundamental wave and a 20 per cent third harmonic in different positions.

A—Peaked Wave	*Form Factor, 1.212*
B—Flat Top Wave	*Form Factor, 1.060*
C—Irregular Wave	*Form Factor, 1.113*

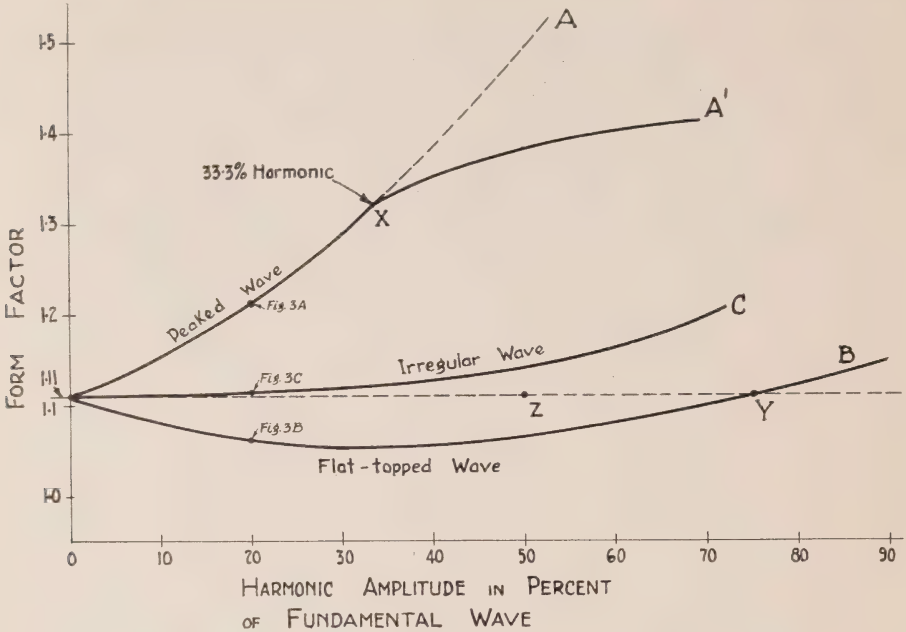

Fig. 4—The effect of the third harmonic upon form factor for the three positions shown in Fig. 3.

factor will be 1.113,—practically the same as that of a pure sine wave.

It is evident then that the third harmonic, according to its position, can cause a wave to be either peaked or flat topped, with form factors respectively higher or lower than that of a pure sine wave, 1.11, or that the harmonic may even be so placed as to give a distorted wave that has the same form factor as the sine wave.

Effect of Harmonic Amplitudes

The effects upon form factor of third harmonics of different amplitudes but in the three positions of Fig. 3, are shown in the graph of Fig. 4.

The form factor of the peaked wave, A, follows a simple formula,—

$$\text{Form Factor} = \frac{1.11 \sqrt{E_1^2 + E_3^2}}{E_1 - \frac{1}{3} E_3}$$

Beyond the point X, however,—i.e. with harmonics greater than 33.3 per cent,—the wave front of the harmonic is steeper than that of the fundamental so the resultant wave crosses the zero line more than twice per cycle of the fundamental frequency. This introduces negative areas which the average voltage voltmeter erects and adds to the positive areas. The curve, therefore, breaks at this point, becoming A^1 and does not follow the formula further. The departure from the original (dotted) curve may be determined most readily by graphical methods applied to plotted or recorded waves.

The form factor of the flat-topped wave, B, follows a formula similar to that of the peaked wave,—

$$\text{Form Factor} = \frac{1.11 \sqrt{E_1^2 + E_3^2}}{E_1 + \frac{1}{3} E_3}$$

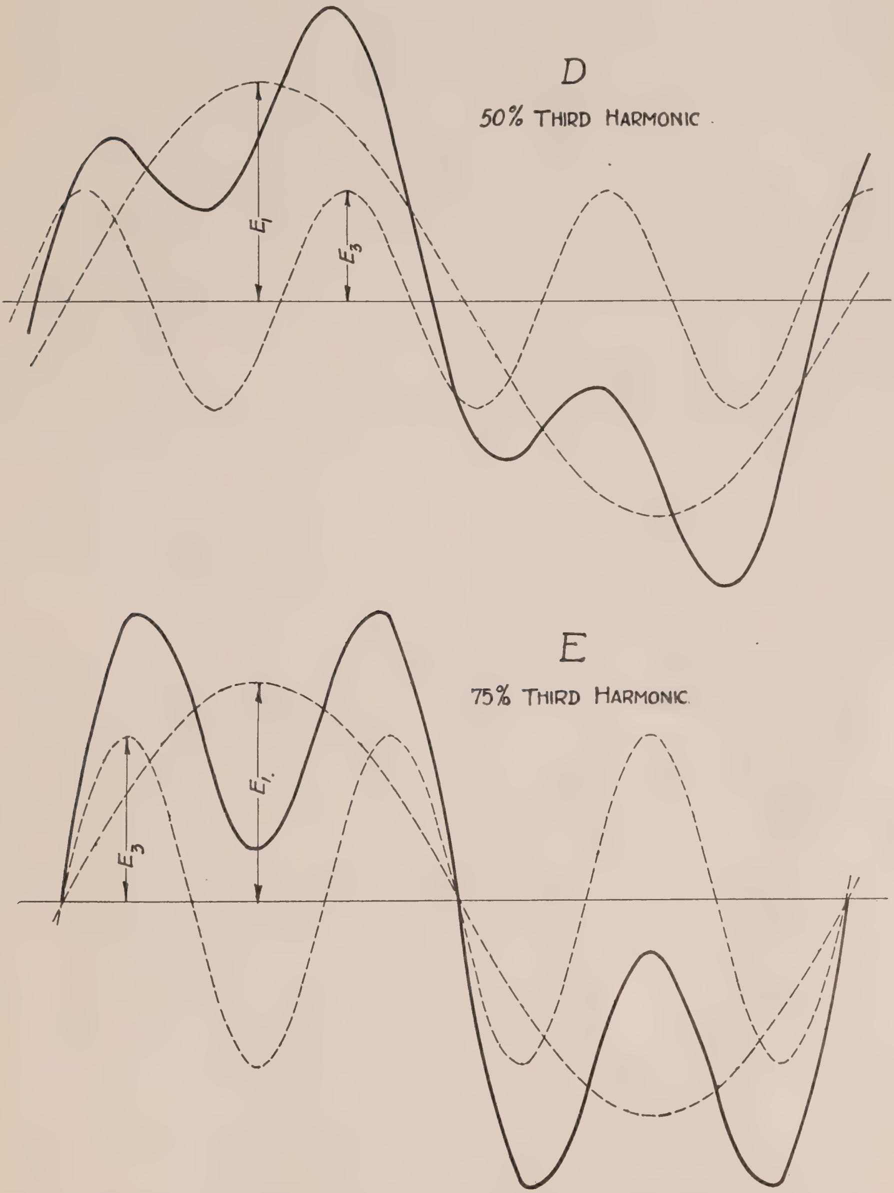

Fig. 5—Wave Forms which have a form factor of 1.11,—equal to that of a pure sine wave.

D—50 per cent Third Harmonic—Position Z, Fig. 4.
E—75 per cent Third Harmonic—Position Y, Fig. 4.

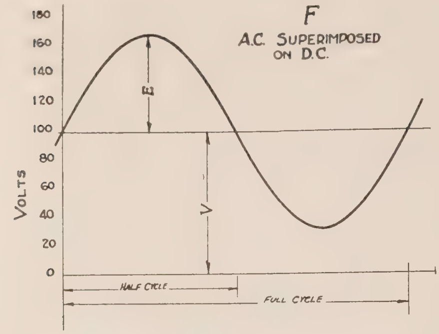

Fig. 6—Alternating Wave superimposed upon direct current. When E=68.1 per cent of V, as shown here, the form factor is 1.11.

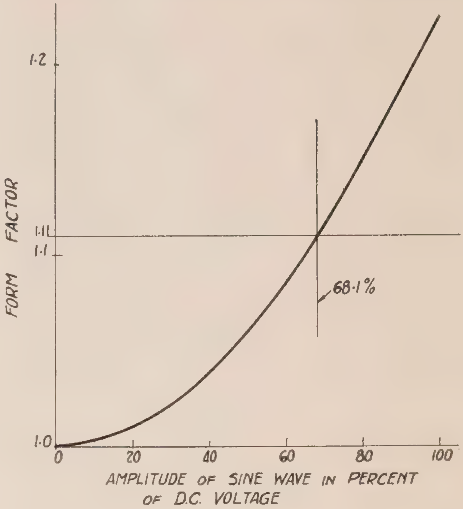

Fig. 7—Variation in Form Factor for Waves of the type shown in Fig. 6, for different ratios of the alternating wave to the direct current value.

As far as the point Y,—75 per cent harmonic,—the form factor is less than that of a sine wave. At Y, the curve crosses that of a sine wave, and beyond Y it is higher. When the harmonic amplitude exceeds that of the fundamental new conditions are found.

The form factor of the irregular wave, C, for harmonics of amplitude up to 20 per cent, is close to that of the sine wave. Beyond that value of harmonic it gradually rises but is lower than the mid-points between curves A and B. The curve C of Fig. 4 represents approximately the wave form of the induced voltage in a single phase transformer when it is excited through a series resistance. The form changes with increased excitation but the form factor may remain practically constant.

From these graphs it can now be seen that a wave with a third harmonic of any amplitude up to 75 per cent may have a form factor of 1.11, that of a pure sine wave, if the harmonic be properly placed for such effect.

In order to show the wave forms, and the positions of large third harmonics, to give the form factor of 1.11, two irregular waves have been plotted, Fig. 5. In the upper wave, D, there is a 50 per cent third harmonic, placed according to Position Z, Fig. 4, but the lower wave, E, has the maximum third harmonic, 75 per cent, which can still produce a form factor as low as 1.11,—Position Y, Fig. 4. These two cases, however, may be only hypothetical and are not likely to be found in electrical engineering practice.

AC PLUS DC

Where an alternating sine wave is superimposed upon direct current, Fig. 6, Wave F, form factor may still be interpreted as the ratio of rms to arithmetical average values. The formula then is as follows,—

$$\text{Form Factor} = \frac{\sqrt{V^2 + \frac{1}{2} E^2}}{V}$$

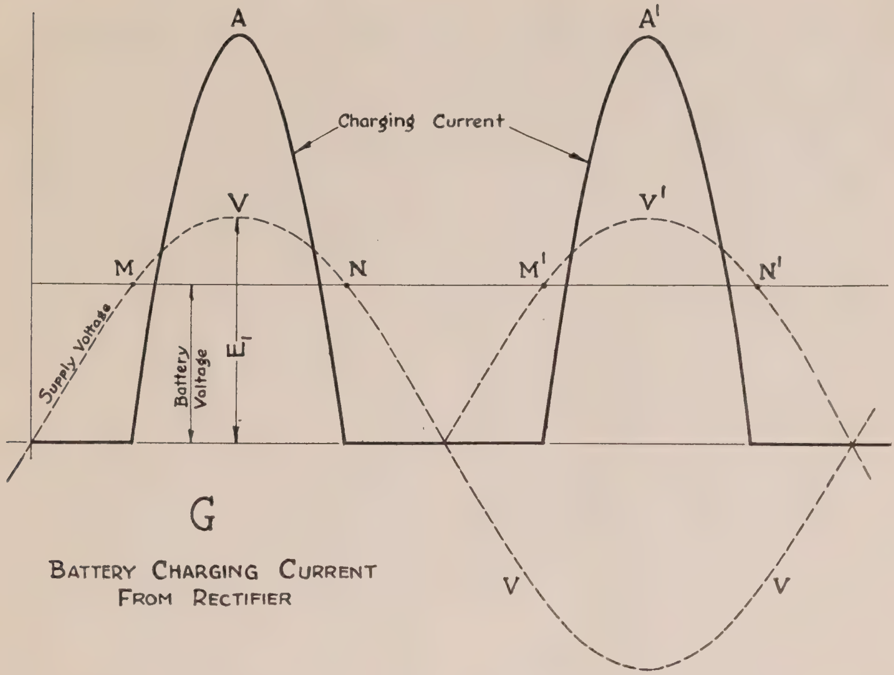

Fig. 8—Charging current from a rectifier to a storage battery,—a highly peaked wave. For the ratio of battery voltage to crest value of supply voltage shown here, 1.41, the form factor with full-wave rectification is 1.54, and for half-wave rectification is 2.17.

The graph of Fig. 7 shows the variations in form factor, according to this formula. When the amplitude of the alternating wave reaches 68.1 per cent of the direct current component, the form factor is 1.11. The wave, F, in Fig. 6, is plotted with this ratio.

Battery Charging Currents

One common method of charging storage batteries is by means of an alternating current supply and a rectifier. The half-wave rectifier permits flow of charging current from only one half of the supply wave, flow from the other half of the wave being stopped completely. The full-wave rectifier, however, erects the negative half of the wave and allows current to flow from each half of the wave alternately but only to flow in one direction through the battery. In either case, the current cannot commence to flow until the instantaneous value of the supply voltage slightly exceeds the battery voltage, at the points M or M^1, and will cease to flow at the points N or N^1.

The current wave, therefore, is highly peaked with a narrow base, as shown in Fig. 8, Wave G, and, as high peaks increase the rms value more than the arithmetical average value, the form factor of such a wave is higher than that of a sine wave. The wave shown, G, has a form factor of 1.54 where a full wave rectifier is used.

Half Wave Rectification

The effect upon form factor of a half-wave rectifier is very striking. There is only one half wave per cycle of alternat-

ing supply voltage. The rms value of the wave is 70.7 per cent of that from a full wave rectifier whereas the arithmetical average value is half. The form factor of the half wave, therefore, is 1.41 times that of the fully rectified wave.

The sine wave through a half-wave rectifier has a form factor of 1.565, whereas by full-wave rectification the form factor is only 1.11, as previously mentioned. If in wave G, the right hand half wave be omitted, so that the charging current is zero during the negative half cycle of the supply voltage, as occurs with a half-wave rectifier, the form factor of this wave would be 2.17. As either the supply voltage or battery voltage changes to narrow the base of the wave in proportion to its amplitude, the form factor would increase still further.

Interpretation of Form Factor

Form Factor has been defined and it may be determined, within certain limits, by means of the rms and arithmetical average instruments but its interpretation may be rather difficult. As a general rule, a form factor higher than 1.11 indicates that the wave is peaked, though not necessarily symmetrical about any vertical axis. A wave with form factor lower than this value will have a flattened top, and may even be deeply depressed.

The form factor of 1.11 is that of a sine wave but, as shown in preceding paragraphs and illustrations, particularly by Fig. 4, there can be many wave forms with third harmonic components which would have the same form factor as the fundamental sine wave. With the addition of still higher harmonics, there would be an infinite variety of waves that have this form factor. It cannot be taken for granted then that the form factor of 1.11 assures a true sine wave.

Neither the rms value, nor the arithmetical average value of a distorted wave can be used to determine its maximum or crest value, and the form factor of the wave does not give definite information in this regard, as may be seen from the following tabulation of data for waves which are shown in the illustrations herewith. (See top of next page.)

It will be evident then from the apparently erratic variations shown in the this table that measurement of the crest value of a distorted wave on an oscillogram can not be used for accurate determination of its rms value, nor of the scale of the wave in connection with an rms reading. Measurements from crest to crest on an oscillogram to calculate rms values may result in serious errors unless the wave be approximately of sine form.

The rms value of current is the heating value whereas the arithmetical average value is the battery-charging or electrochemical value. Where a half-wave rectifier type of charger is used, and the charging current is read on a direct current permanent magnet type of ammeter, protective fuses rated at twice the indicated charging current may blow readily for the heating value, i.e. the fuse—blowing value, of the current may be three times the charging value, or more. The form factor then would be 3.0, or even higher.

In testing alternating current equipment which has magnetic circuits, both the magnetizing current and the iron losses are affected according to the form of the applied voltage wave. The peaked voltage wave, A, causes errors in giving lower values than the sine wave would give. The flat-topped wave, B, gives

Wave Form	Crest Value	RMS Value	Arith. Average	Form Factor	Crest Factor
Sine Wave	10.0	7.07	6.37	1.11	1.41
Square Top Wave	10	10	10	1.00	1.00
Peaked Wave A	12	7.2	5.95	1.212	1.66
Flat Top Wave B	8.8	7.2	6.8	1.06	1.21
Irregular Wave C	11.1	7.2	6.48	1.113	1.54
Irregular Wave D	13.5	7.9	7.12	1.11	1.71
Regular Wave E	13.2	8.84	7.95	1.11	1.49
AC plus DC—F	16.8	11.1	10	1.11	1.68
Charging Current—G					
Full Wave Rectifier	18.0	9.40	6.10	1.54	1.92
Half Wave Rectifier	18.0	6.62	3.05	2.17	2.72

The Crest Factor, or Peak Factor, is the ratio of crest value to rms value.

higher readings of core loss and exciting current than should be obtained. A variety of voltage waves, all with form factor equal to the sine wave as chosen by reference to Fig. 4, may still give errors in reading these important quantities. The indications of rms and arithmetical average instruments, however, are definite measurements of real and recognized quantities.

The average voltage voltmeter is of considerable assistance in obtaining correct iron losses, i.e. the losses that would be found with a sine-wave voltage of normal value. This, however, does not solve the problem of correcting exciting current for sine-wave voltages. As mentioned earlier, certain methods of correction of core losses and exciting currents of transformers are being advocated by the American Standards Association in its recommended "Test Code for Transformers". These are based on form factor and the use of the average voltage voltmeter. With increasing importance being placed upon the sine wave of voltage in testing electrical apparatus, and upon correction of readings when voltage waves are not of sine form, it is probable that the average voltage voltmeter will be more generally applied, and a knowledge of form factor and its interpretation will be very useful. The above information therefore will be supplemented in an early issue of *Electrical News and Engineering* by a discussion of corrective methods and the application of the average voltage voltmeter for this purpose.

Comments on Blackouts

By S. G. Hibben, Director of Applied Lighting, Westinghouse Lamp Division, Bloomfield, N.J., and Kirk M. Reid, Illuminating Engineer, Engineering Department, General Electric Co., Nela Park, Cleveland, O.

BLACKOUTS in the Western Hemisphere have become sudden actualities! Regardless of more than two years of observation and reports of European methods, the American citizen is largely unfamiliar with the fundamentals of blackouts, or he feels with reason that our problems differ sufficiently from those of London to justify a considerably different solution. Moreover, our civilian authorities are confronted with floods of suggestions and a dearth of specific data, and some time must elapse before agreements will be reached on many details. In the meantime, and in an effort to summarize what seems to be a representative studied opinion of lighting experts, the following items are pertinent.

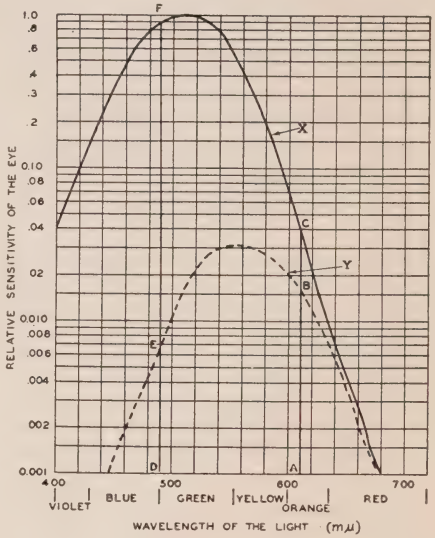

Fig. 1—Curve Y represents the normal eye sensitivity under normal lighting. Curve X represents the sensitivity of the dark-accustomed eye under very dim illumination.

At varying points below moonlight values (less than 0.02 footcandle), the sensitivity curve of the eye shifts towards the shorter wave lengths, and the Purkinje effect grows noticeable. Absolute or instrument measurements do not agree with the personal observations; hence one speaks of "apparent" footcandles or footlamberts. Colors of objects in dim light are difficult to distinguish—or lost altogether. The curves of Fig. 1 show why the dimly-lighted blue object, seems brighter than a red one. (Ordinate DF exceeds DE). Since the visibility of a target is actually based on its appearance to the observer, the records of footcandles are of little use. Rather the "apparent footlamberts" become the significant characteristic in connection with "dim-out" provisions or specifications. The Purkinje effect becomes an important and increasing factor at brightness values of 0.1 footlambert and below.

Eyes are called upon to function over night ranges that include indoor illumination on the order of 50 footcandles to outdoor values of 0.0002—the latter being the British standard for average emergency street lighting during wartime. While it is true that one can see larger objects under even less than starlight

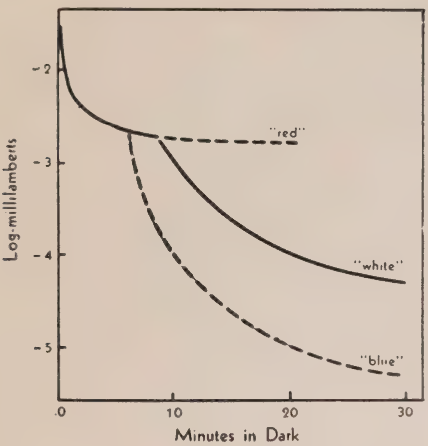

Fig. 2—Progression of Threshold. Two-degree field five degrees from fixation point. Data on "white" by Hecht; interpreted for "red" and "blue" by Adams.

illumination, yet fields of view must be large and time for adaptation long. Under the hasty and uncomfortable conditions of a pilot's seeing, it seems generally impossible to detect ground targets unless illuminated to values of 0.0004 footcandle, or a trifle greater.

The time required for an observer to become dark adapted depends upon the brightness and color to which his eyes were previously exposed, the color for which the threshold is determined, his age, and to some extent the condition of his eyes, his general physical condition and other factors. Fig. 2 shows that some thirty minutes are usually required for dark adaptation to become substantially complete under "white" or "blue" light, as compared with about seven minutes under "red". Fig. 2 also shows the approximate ultimate thresholds reached by dark-adapted observers. These thresholds depend upon the color for which the threshold is determined, the observer's nutrition (Vitamin A), the condition of eyes and other physiological factors.

The continuous blackouts of Europe have not afforded immunity from air attack and in all reasonableness would not do so here. Let us not, without first carefully weighing all costs and understanding the limited benefits, confuse and endanger ourselves with hysteria-bred blackouts or dim-outs of street lighting. Not when 4,500 fatal road accidents have accompanied continuous blackout in England during each of the past two years. Not when pedestrian fatalities doubled at night. Not when our American traffic densities are generally much greater—our hazard of bomb damage much less! Indeed, it should be remembered that except during an actual emergency the most effective conduct of our whole defense activity requires the best possible visibility on streets and main highways for safe and rapid movement of men and materials. We need the full value of our present street lighting, with flexibility of control to permit turning it out quickly when a blackout is ordered and a quick return to normalcy when all is clear.

During so-called complete blackouts on moonless nights, street lighting of the order of "starlight" values—on main arteries, through truck routes, access roads to war industries, and other locations of emergency movement—will doubtless be found of value here as it has in England. But where ordered it should be supplied by a separate, alternative system which does not detract from the effectiveness of the normal street lighting.

Blackouts within important factories are not to be condoned, except during raids which destroy obscurement measures. Production must not be thus disrupted. Nor should production be hampered by

dim-outs or by reversion to spotlighting systems which cause eye-strain and fatigue, with the inevitable accompaniments of decreased production, increased spoilage, and lowered morale. Such lighting curtailments in effect achieve the very end sought by air attack—delay and disorganization of the civilian war activities. Instead, suitable means should be employed for (temporary) obscurement of factory windows and other openings, thereby permitting the conservation of time and man-power gained through extraordinarily adequate lighting for seeing and by unhampered production for victory!

Among the many instruments and methods, or the ideas that can be useful in air-raid protection, may be listed the following:

1. Bombers at night usually fly high, generally above 20,000 feet, and observe large areas. At or slightly below this elevation, a flyer over Washington could see Baltimore, etc., and hence blackout measures will have to be flexible and executed promptly after a warning. To be concealing, they should be made over large areas. A quick return to normalcy after "hit-and-run" bombing is preferable.

2. Lighted vertical surfaces are as important as roof tops and horizontal ones, remembering that the bomber lines up his target perhaps from three to ten miles ahead of his position. Furthermore, he knows his approximate location even at night by following outlines of rivers, bays, shiny railway tracks, etc. He may even fly a radio beam or can drop a flare or incendiary bomb and thus know he is over a city. The military function of a blackout, then, is not complete concealment. Its great value is that the location and identification of vital targets is thus made more difficult. It is a delaying action.

3. Blue light during blackouts is least helpful to those on the ground and most likely to be detected from the air. Dim "white" or reddish light is to be preferred.[1]

4. In areas likely to be attacked, the first street lighting precaution is to check circuits and make provision whereby the major present street lights can be extinguished quickly when a blackout is ordered. Street lighting circuits, especially the series type, controlled from utility stations can usually be turned off within a few seconds after the attendants receive a raid warning. Circuits controlled from outlying points or on the regular multiple network should preferably be turned off by trained air-raid wardens, if simple switching facilities can be provided, thereby permitting utility personnel to concentrate on the vital task of maintaining electric service. Extinguishment of gas units seems to be a post-to-post patrol job.

5. Wherever extended and continuous blackouts are likely to be ordered, plans should be ready for an alternative "starlight" blackout street lighting system, on streets where pedestrian and vehicular traffic must continue to move. It would be desirable to obtain the consultation and approval of the proper military authorities before installing blackout street lighting.

6. Since the wattage of blackout street lighting is low, it is likely that manpower, material, and money will be conserved by connecting the limited number of luminaires to available multiple circuits and burning them continuously without switching provision. Further, such con-

[1] "Visual Aids to Traffic Movement Under Blackouts," W. S. Everett and Kirk M. Reid, *Illuminating Engineering*, December, 1941, p. 1184.

nection insures that the blackout lighting will be on when needed. If necessary to conserve copper, iron wire may be found to be a compromise for serving low-wattage blackout street lighting.

7. Temporary shields on ornamental street lighting globes or other modifications of existing upright or pendent street lighting luminaires are not likely to provide sufficient concealment from the air to be approved for use during blackouts unless very carefully executed. The difficulty of attempting such modification is indicated by the report that dark-adapted aerial observers may detect a lighted match from 10,000 feet. It is noteworthy that rather than to illuminate dimly the road surface, it would be desirable to illuminate the torso of the pedestrian and keep the light off the pavement.

8. Reduction in operating current or voltage or decreases in the number or size of lamps in present street lighting are not to be recommended. Such practices simply increase the traffic hazard with no significant decrease in the ease of detection and identification from the air. An exception might be unusual cases of lighting camouflage, or to reduce sky-glow near seacoasts.

9. Electric advertising signs, building floodlighting, gasoline service station lighting and other exterior lighting should of course be extinguished during blackouts. One method of control which appears to be working satisfactorily is use of a switch actuated by a photo-cell controller directed toward the nearest street lamp. Such control may be applied to show-window lighting and other interior as well as exterior lighting. However, manual control (by janitors or wardens) is now preferred.

10. During blackouts, civilian automobiles should pull to the curb and stop, extinguishing all lights, unless provided with an approved auxiliary blackout headlight and rear and front markers of approved design. No entirely satisfactory way has been found whereby the individual can improvise satisfactory shields for existing lights for extended driving. Drivers with approved blackout lighting should not proceed at more than twenty miles per hour and not in close procession.

11. It would be desirable for all taxicabs and commercial vehicles to have a wide band of white paint across the body or on the fenders. Each civilian car might have a white canvas ribbon to tie across the hood and around the back, plus a liberal use of reflex reflector buttons to make the car more visible at night. Reflector targets on highways are extremely helpful. Phosphorescent metal, fabric or plastic markers are useful. These, after some three minutes of darkness, seldom exceed 0.01 footlambert.

12. Automobiles parked in closely-packed lots and with shiny tops will reflect any overhead light clearly. If cars must be so parked in the vicinity of important objectives, the parking lots may well have suitable camouflage. The cars themselves, particularly the bright metal parts, might be sprayed with a dull drab wash if no other means should be feasible to make them less visible from the air. Dew on any dark surface makes it a rather good reflector.

13. Pedestrians walking abroad during blackout in congested districts should wear reflex markers or a prominent piece of white goods below the knees—white spats, shoes, anklet, or a handkerchief tied around the ankles. The reason for a low

white area is that blackout headlights may be expected to throw little light above waist level. If pedestrians carry portable flashlights, they should be of the smaller sizes with screened or hooded ends as afforded by a tube of cardboard, a short section of bicycle inner tubing, etc. (Never point flashlights upward.)

14. It may be found helpful to equip major traffic officers with fluorescent capes and gloves and hang a black light unit overhead such as the mercury lamp, type C-H_4 with purple filter. Fairly good fluorescent paint is available to mark smaller objects under black light. Phosphorescent portions of uniforms are feasible.

15. Unless blackouts become frequent and of long duration, traffic signals should be kept in normal operation with provision for turning them off quickly when ordered during blackouts. Control of traffic at important street intersections should then be handled by regular or volunteer policemen using special luminous equipment being designed for this purpose.

16. Masks which permit standard traffic signals to remain in use during blackouts necessarily emit so little light that the signals are virtually useless during the daytime and are seriously deficient for normal traffic movement at night during non-blackout periods. It may be found possible to operate standard traffic signals during blackouts by use of long hoods and under-voltage operation of the lamps. An alternative blackout traffic signal, where found necessary, is likely to be a more satisfactory solution.

17. Translucent signs to burn at vulnerable places during raids should preferably not be visible from the air at any angle at a distance greater than 1,000 feet.

18. Glare sources reduce the visibility of nearby targets but represent a special form of camouflage that limited equipment makes questionable at this date. Rapid flashing, on the order of two to five flashes per second, apparently confuses an observer more than steady sources.

19. In outdoor sub-stations, or away from polished surfaces, one possibility is the use of low-candlepower lamps, preferably hooded, a few inches above the ground level to assist safe patrolling. In power stations a small amount of interior illumination, particularly on instrument panels and walkways, will probably be found adequate for emergency operation and invisible from the air, particularly if windows are screened to a reasonable degree.

20. Means of obscurement of windows in factories are discussed in detail in the bulletin, "Blackouts", published by the Office of Civilian Defense, Washington. The preferred method of obscurement is by means of light-tight shutters or drapes which can be put into position quickly when a blackout is ordered. This bulletin also explains fully how light-traps may be employed for ventilation and for movement through outer doorways.

21. Phosphorescent paints, excited or charged by visible light (not necessarily "black" light and luminescent plastics may mark critical objects or indicate safety devices, etc. The better grades will glow for several hours (roughly 0.1 microlambert after five hours.)

22. For hospital service and at switchboards or vulnerable parts of industrial plants, good uses may be found for portable, rechargeable, miner's cap lamp outfits of proper design for use during blackouts. Such outfits may also prove valu-

able on street cars, buses and in the hands of wardens and special police.

23. Electric services are seldom eliminated by bombing, but lighting facilities within private structures should be doubly assured by spares. Service entrance switches should not be opened except as a very last resort. Switch controls should be made flexible and wiring so arranged that sections or rows of units near windows are separate from those deeper within the building.

24. The important objective of blackouts is elimination of artificial lighting which may be detected and interpreted quickly by qualified, dark-adapted, aerial observers at a reasonable altitude, say 5,000 feet. It is noteworthy that this objective does not require elimination of all lighting which can be seen by nearby ground observers. The aerial studies of the responsible military authorities are the proper guides to safe blackout lighting practices.—*Illuminating Engineering.*

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The foregoing article is published for general information, The Hydro-Electric Power Commission of Ontario taking no responsibility for any statements contained in it.—Editor.

Magnetostriction Phenomena

By Wm. D. Williams, General Engineering Laboratory, General Electric Company

THE extent to which magnetostriction is involved in the preparation and behavior of magnetic materials is being realized today more than ever before. In consequence, it is becoming increasingly important to science and industry. Large laboratories throughout the country are now devoting more and more attention to accurate study of this subject with modern materials and equipment. This article presents a brief review of fundamentals of the phenomena and of various significant observations to date.

In magnetic materials, magnetization is accompanied by changes in physical dimensions. Conversely, in the same materials, changes in magnetic properties are produced by mechanical stresses. These effects are known collectively as magnetostriction and have long been recognized separately under various names according to the nature of the effect.

Mechanical Effects

The mechanical effects which accompany the magnetization of a specimen of ferromagnetic material are classed according to the sort of deformation produced. The changes in length parallel to magnetization in a specified direction or perpendicular to this direction are called, respectively, the longitudinal or the transverse Joule effect. Usually when the length is increased the transverse dimensions are decreased and vice versa, so that the resulting change in volume may be extremely small. Observations of the volume magnetostriction or Barrett effect

have been made, but only with great difficulty. The bending which accompanies magnetization, or the Guillemin effect, has also received very little experimental attention. On the other hand, the twist resulting when circular and longitudinal fields are applied simultaneously to a rod specimen, called the Wiedeman effect, has been the subject of many investigations by early workers.

Magnetic Effects

Each of these mechanical effects has its reciprocal magnetic effect. With the application of tension or compression the resulting change in magnetization parallel to the direction of the stress is called the longitudinal Villari effect and the change in magnetization perpendicular to this direction is the transverse Villari effect. Thus, the Villari effects are the converse of the Joule effects. There is also a converse of the Guillemin effect, namely, the change in magnetic flux produced by bending a ferromagnetic rod in a longitudinal magnetic field. The longitudinal magnetization due to twisting a circularly magnetized rod is the inverse Wiedeman effect. The closely associated effect in which circular magnetization is produced by twisting a longitudinally magnetized rod is called the Wertheim effect. Finally, the change in magnetization resulting from a change in volume is called the Nagaoka-Honda effect and is a reciprocal of the Barret effect.

Other Phenomena

A number of other magnetostriction phenomena are not reciprocal in character. Important among these are the variations in Young's modulus, the modulus of rigidity, and the bulk modulus. The effect upon Young's modulus has received more investigation than the other elastic constants, although the coefficient of rigidity is apparently affected more than the others by magnetization.

These various magnetostrictive effects involve dimensional changes of length, twist, and volume, the magnitudes of which are in most instances extremely small. For example, in common materials, the Joule effect is of the order of 10^{-6} inches per inch, and the Barrett effect is of the order of 10^{-7} cubic inches per cubic inch. Consequently, very sensitive methods of measurement have to be employed to study them. An even greater experimental difficulty to be overcome is that of separating various effects which may exhibit themselves under the same test conditions. This is especially true of experiments with the Guillemin effect in which one part of the test specimen is under tension while another part is compressed. In addition, all work with magnetostriction is faced with the difficulty of obtaining specimens which are magnetically perfectly uniform.

All of the effects described above are forms of magnetostriction. Consequently, magnetostriction plays a part in almost all work in which ferromagnetic materials are used. When either stresses or magnetization are present in these materials, magnetostrictive effects must also be present, and in many kinds of work the extent to which they are present is extremely important. Metallurgists are familiar with the tremendous changes in magnetic properties which are produced by heat treatments, deformation such as cold-working or hot-working, or phase changes within the materials. A well-known application of these effects is found in the treatment of permanent-magnet materials in which the stresses resulting from quenching, precipitation, or mechanical deformation aid in producing

the desired permanent-magnet characteristics.

Sometimes the magnetostrictive effect of stresses is undersirable. Everyone familiar with magnetic testing knows the spurious results which may be obtained from a test specimen which is accidentally bent or clamped too tightly in the testing equipment.

Magnetostrictive changes in dimensions are perhaps less familiar than the reciprocal effects because the changes in dimensions produced by magnetization are very tiny. The Joule effect, which has been studied more perhaps than any other involving measurement of dimensions, usually requires displacement measurements of the order of millionths of an inch, and in work with single crystals or other small specimens even smaller distances must be measured.

Measuring Methods

Special extensometers of high magnification are necessary for this work. The commonest types of these machines employ either mechanical or optical amplification, or both, to permit accurate measurement of the change in length. The required magnification is usually obtained with optical levers, rotating mirrors, or optical interference methods. Other schemes sometimes used involve measurements of changes in the electrical capacity or inductance of apparatus connected mechanically to the test specimen.

Investigations carried on with this kind of apparatus have revealed the influence upon the Joule effect of temperature, tension, compression, and the shape of the specimen and have shown the existence of a hysteresis effect. On account of the influence of so many different factors, special techniques are necessary for controlling and measuring the desired phenomenon. Therefore, in comparing the Joule effect in various different materials accurate temperature control must be provided, the specimens must be of the same size and shape and must be held with the same amount of tension or compression and to take account of the hysteresis effect the magnetizing field must be applied when the specimens are in the same cyclical magnetic condition.

Tests of this kind have permitted metallurgists to study the effect of composition and treatment upon the magnetostrictive properties and have aided in the selection and manufacture of materials having properties required by widely different applications.

Considerable work has been done in the past with magnetostriction oscillators in which the application of an alternating magnetic field of appropriate frequency caused a rod or tube of material having a large Joule effect to vibrate longitudinally. When the natural frequency of vibration of the rod and the frequency of the magnetic field were properly adjusted, resonance magnetostriction oscillations of considerable amplitude were produced. In some cases amplitudes have been obtained which were so large that their measurement by direct observation through a powerful microscope was possible.

A serious disadvantage of this early type of oscillator was the wide variation of mechanical stresses along the rod, the stresses being a maximum at the clamped center and zero at the free ends. Therefore, the modern magnetostriction oscillator is usually in the form of a closed circular ring wound with a uniform toroidal winding which permits all parts of the ring to vibrate radially with the same amplitude and phase. Calculation of the

amplitude of vibration at various frequencies shows that the resonance peak is very sharp and it is for this reason that magnetostriction oscillators are especially suitable as standards of frequency.

Magnetostriction oscillators capable of producing intense vibrations limited only by the mechanical strength of the magnetic material have been used in experiments with the effect of such vibrations upon metals, colloids, and bacteria. Sonic radiation produced in this way has been used to kill frogs, fish, larvae, and water fleas. Bacteria were killed so quickly that partial sterilization of milk in continuous process was effected.

Stress measuring devices depending upon the Villari effect have been used for the study of transient mechanical stresses. The stress is applied by suitable mechanism to the ferromagnetic core of a transformer and the resulting magnetic changes in the core are observed by the help of appropriate electrical circuits.

The applications described above depend upon materials having large magnetostrictive effects, but there are other applications in which a minimum of magnetostrictive changes in dimensions are required. Examples of these may be found in alternating-current machines and other devices using magnetic materials in which magnetic hum is present. Although this hum is a dynamic effect, most of the investigations made to aid in producing steels in which the hum is minimized have been concerned with the Joule effect produced by direct-current magnetic fields.

In measuring the Joule effect in steels, test specimens of standard shape and size, known as "Epstein" specimens have generally been used in order to correlate their magnetostrictive behavior with the results of other magnetic tests made with these specimens. The magnification necessary for measuring the tiny changes in length obtained by magnetizing such short specimens is of the order of 50,000:1. Magnifications as large as this have been obtained with a simple optical system employing a small mirror fastened to a rod 5 or 10 mils in diameter whose rotation is a measure of the change in length of the test specimen. More recently a precision extensometer has been developed in which optical interference bands are counted as a measure of the Joule effect in "Epstein" specimens.

SUMMARY

Magnetostriction phenomena include many widely different effects which fall under two general classifications: (1) the changes in physical dimensions which accompany magnetization of magnetic materials: (2) the change in magnetic properties due to mechanical stresses in these materials. The existence of these magnetomechanical relations has been known for many years, but more recently their close connection with the preparation and behavior of magnetic materials has been realized more fully than ever before. As a result, magnetostriction has become increasingly useful to science and industry through the direct application of magnetostrictive effects and as an important factor which accompanies many other magnetic phenomena — *General Electric Review.*

How to Dramatise a Bald Statement

TO say that glass is a substance of many uses and that it is an indispensable material in the arts and crafts is to state an uninteresting platitude. But salesmen and drafters of technical publicity matter should be interested in seeing how a mere list of uses may be transformed into a recitation of almost dramatic effect. It is due to Mr. George J. Overmyer, a distinguished American writer, who puts it thus:—

I AM GLASS

I am created of the admixture of Earth's minerals formed by the alchemy of time.

I am born transformed in the blasting heat of fiery furnace.

In molten mass I am tediously fashioned by the hand of cunning Artisan—or fed into the maw of intricate machine.

I assume ten thousand hues of all the spectrum—either transparent, translucent or opaque—upon my maker's will.

I can masquerade as ruby—emerald—topaz—moonstone; and all the other priceless jewels of man.

But frivolous baubles are not my aspiration—I serve ten million purposes in as many different places, forms and ways.

My duties are unnumbered—infinite; pay heed to my utility;

I admit the Heavenly light to hovel, palace or cathedral, and yet repel cold winter's howling breath.

I faithfully project the light that warns great ships from shoal and concentrate the beams that guide swift vehicle through storm and gloom of night to bring the wayfarer safe home.

I visibly contain my master's food—his drink—and countless other of his commodities; protecting them in transport and in the mart and home.

I form the shell of glowing bulb and tube to diffuse his artificial light—and to disseminate his advertising.

I am the walls of his abode, his office and his factory—and objects of utility and art in each of these.

I reflect his image—and mark the effects of time upon his person—sometimes I flatter but more often am critically severe.

I correct his impaired sight and thus bestow enjoyment of the printed word—and all of Nature's beauties roundabout.

I magnify his minute, unseen enemies and thereby do I promote his health and happiness.

I form the gossamer thread from which is fashioned fine raiment—yet too the insulation of his dwelling.

I reveal to him the mysteries of his Universe—carrying his vision to the illimitable reaches of the outer stars.

Through me he learned to chart the Firmament—to plot the orbits of the Planets and predict the courses of the Comets and Eclipses.

This knowledge I unfold is but the pledge of vaster knowledge as—step by step—I lead him to unexplored, immeasurable spaces.

For I am older than the Pyramids yet newer than tomorrow's unborn dawn—withal the marks of time affect me not—for I am ageless and retain my lustrous beauty permanently.

Some of my tasks I have recounted—but this is only the beginning! for those

who make me and adapt me to their uses, are men of vision—and together, as time unfolds, we will go far.

And so—in modesty I proclaim—I am Man's invaluable and versatile servant—I AM GLASS.—*The Electrical Times.*

L. A. S. Wood

MANY Canadians will learn with regret of the passing of L. A. S. Wood who died suddenly on May 6, 1942, at Cleveland, Ohio, after a very brief illness. One of the most outstanding illuminating engineers on this continent, Mr. Wood was Chief Lighting Engineer of the Westinghouse Electric & Mfg. Company, a past President of the Illuminating Engineering Society, and a member of the American Institute of Electrical Engineers. He had been associated in the lighting industry ever since he began his career, and was a pioneer in promoting good practice for street and highway lighting, not only in this country but also in England.

He was born in London, England, and received his education at the City of London School of the University of London. Afterwards he studied electrical engineering under Professor P. Thompson at Finsbury Technical College.

He took a leading part in laying out street lighting systems in the larger European cities and also the lighting of many public buildings for the British Government.

Mr. Wood came to the United States in 1911 to introduce the Flame Carbon Arc Lamp, and was shortly afterwards appointed Arc Lamp Expert for the Westinghouse Company, East Pittsburgh, Pennsylvania. He was an illuminating engineer of the George Cutter Company and later sales manager.

During the past twenty years Mr. Wood has traveled extensively, always taking an active interest in the improvement and development of street and highway lighting. Through his efforts many cities have adopted measures and introduced campaigns to cut traffic fatalities and accidents.

Among his many accomplishments in this capacity was the planning, design and sale of the largest individual street lighting system in the country at St. Louis, Missouri.

Mr. Wood served as Consultant on Lighting for the Chicago Exposition and the Great Lakes Exposition at Cleveland, Ohio. He was chiefly responsible for the lighting of the exposition at Barcelona, Spain and the Philadelphia Centennial in 1926.

Mr. Wood visited Canada on many occasions, and will be remembered by men who in various ways are associated with street and highway lighting. Although living in the United States for more than thirty years, Mr. Wood retained his status as a British subject.

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